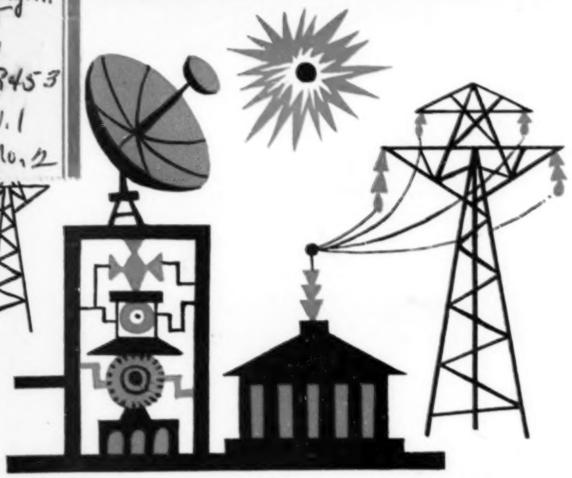
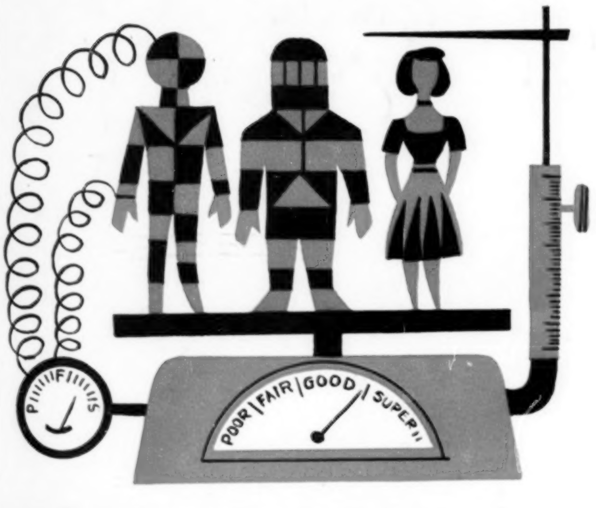
R/E
RESEARCH & ENGINEERING
MAGAZINE OF RESEARCH & DEVELOPMENT MANAGEMENT

SEPTEMBER 1955



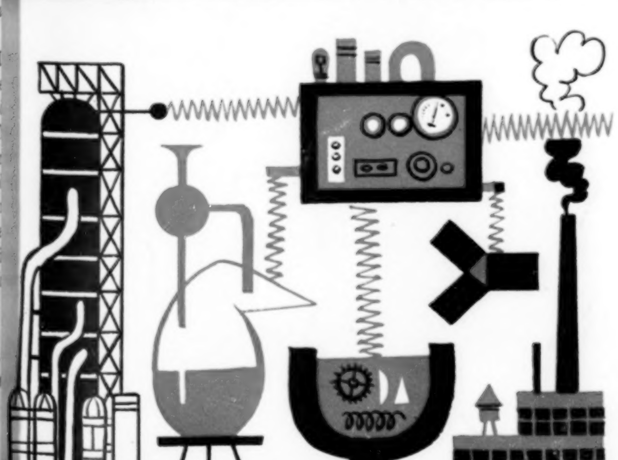
SOLAR ENERGY

R/D chemists and engineers gear for a major onslaught on this next vast source of energy



HOW'S YOUR STAFF EFFICIENCY?

18 ways to get the most from your staff



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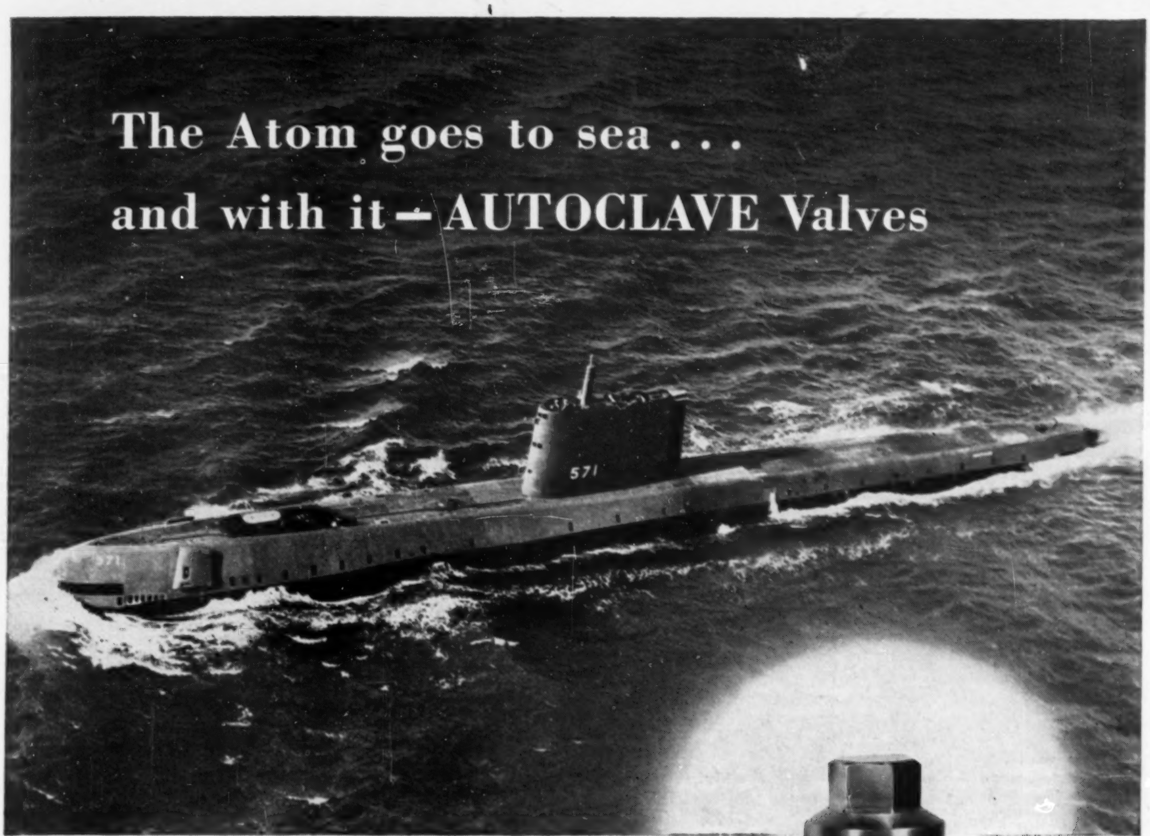

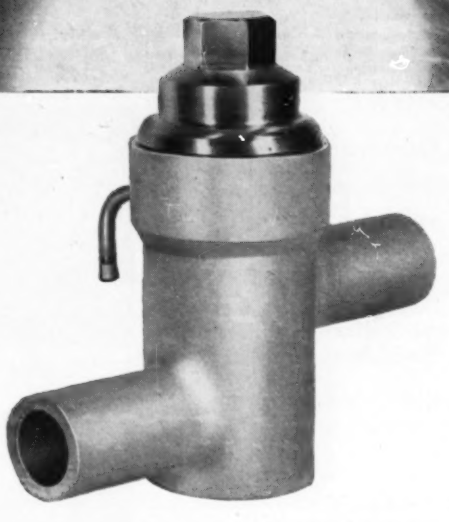

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R/E

VOLUME 1 — NUMBE

SEPTEMBER, 1955

THE MAGAZINE OF RESEARCH AND DEVELOPMENT MANAGEMENT

THIS MONTH'S CONTRIBUTORS

ROBERT ROD
Acoustica Associates, Inc.

A graduate of Georgia Tech, Robert Rod spent three yea as a Radar Officer in the USAF. During the following t years he was associated with Radiomarine Corporation America; Melpar, Inc.; and Bogue Electric Manufacturi Company before establishing Acoustica Associates, In in Glenwood Landing, L. I.

CLARENCE HOTCHKISS, JR.
Stow Manufacturing Company

After receiving his M. E. from Yale University, Clarenc Hotchkiss, Jr. served in the Army as Assistant to the Chi Engineer of the Automotive Division at Aberdeen Provin Grounds, Maryland. As an application engineer for Sto Manufacturing Company, he works on the design of speci flexible shafts, both power drive and remote control f all types of applications.

ALEXANDER C. WALL
American Machine and Foundry Company

Alexander C. Wall has been closely associated with t development of special batteries and resistors, radar tune high frequency aircraft engine ignition systems and t proximity fuse. Currently Director of AMF's Research a Development, he has functioned in a variety of engineeri capacities on automatic pinspotter development, bake machinery and atomic energy projects.

CLINTON F. HEIL
Ordnance Research Laboratory

Clinton F. Heil holds B. S. degrees in Physics and Educ tion and an M. S. in Mathematics. He was a member the Harvard University Academic Staff for two yea working in the Underwater Sound Laboratory and is pre ently with the Ordnance Research Laboratory as Assista Director in Charge of the Engineering Projects Divisio

CHARLES A. SCARLOTT
Stanford Research Institute

Co-author of several technical books including "Fund mentals of Radio", "Electronics for Industry" and "Ener Sources", Charles A. Scarlott established "The Westin house Engineer" and edited it for 14 years. He is n manager of Technical Information Services at Stanfo Research Institute.

RESEARCH & ENGINEERING

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RESEARCH & ENGINEERING

103 Park Ave., New York 17, N. Y., LE 2-054

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Notes

R/E's Flood

An immediate result of the publication of our July-August issue was a gratifying deluge of letters that has now subsided to a steady flow. Pages 6 and 8 contain representative thoughts and opinions of only a small number of those who wrote to us. Our publishing philosophy embraces the belief that each and every reader who takes the time to write even a one sentence letter deserves a quick acknowledgement in some form. Although we have now set up an acknowledgement procedure, it will take some time to process the backlog that has accumulated over the past two months. Thus, if you haven't heard from us, it is not because we are disinterested in your comments. Indeed, we are interested to the extent of answering each letter in the individual manner it deserves, particularly those that referred to our editorial objectives and format and asked questions or made suggestions. To you who did write: our thanks for your effort, time and comments.

Solar Energy: A Change in Strategy

Solar Engineering has had a long infancy—from ancient to present times. And although we are now more ingenious in its utilization than our predecessors, we cannot truly say that solar engineering as an industry is even in its adolescence. But it may soon enter this stage under the combined efforts of the Association for Applied Solar Energy, the Stanford Research Institute and the University of Arizona. These three institutions are sponsoring a "Conference on Solar Energy—The Scientific Basis" on October 31-November 1 at the University of Arizona in Tucson and the first "World Symposium on Applied Solar Energy" November 2, 3, 4 in Phoenix, Arizona. Financial support for this concentrated direction of effort comes from The National Academy of Science, The National Science Foundation, The Ford Foundation, The Rockefeller Foundation, The Office of Naval Research and the U. S. Air Force.

The seriousness, vigor and intent of this organized effort to tap the largest source of energy known to man can best be had by quoting the background and objectives of these meetings from the brochure of the sponsors.

Background: "Recent developments in the laboratory give promise that man's age-old dream of using solar energy directly may be realized. These include advances in solid-state physics, better understanding of forced culture of low-order plants and animals to produce both fuel and food, and the prospect of performing organic and inorganic photosynthesis without the aid of plants and animals. Also, because of the fast-rising burdens being placed on the reserves of nonrenewable fuels it is becoming more important to learn how to draw on the sun as an inexhaustible source of energy. These facts and concepts suggest that the time is ripe to bring together the scientist, the engineer, the businessman and others who can contribute to reducing to practical form the findings of the laboratory."

Objectives: "... the Symposium will provide a common meeting ground for research workers throughout the world and those of industry, business and government who are interested in hastening the day of solar-energy utilization. Technical sessions at the Tucson section of the Symposium will give opportunity for presentation of volunteer papers and for open discussion of the details of specific phases of solar-energy capture. At Phoenix, papers giving summaries of work done and recent new findings in the major fields of solar energy will be presented by the outstanding authorities from many countries. An exhibition of solar devices, brought from several countries, will show the present state of engineering development, and indicate areas where engineering effort should be directed. It is hoped that from these five days of programmed discussions will emerge a clearer picture of the unsolved problems, their relationships and indications for additional research and engineering developments."

Charles Scarlott, starting on page 36, gives you a preview of the present status of solar engineering and the areas in which research and development efforts are most likely to be concentrated.

The High Art of Serendipity

A little over 200 years ago, Horace Walpole coined the word "serendipity" in a fairy tale titled "The Three Princes of Serendip". (Serendip or Serendib is an ancient name for Ceylon). He defined the word to mean the art of making lucky and unexpected finds by accident. In a letter written in 1754, he said that he based it on the title of the book because ". . . princes were always making discoveries, by accident and sagacity, of things they were not in quest of." Current usage applies the term to useful developments that result from accidents or mishaps such as the vulcanizing of rubber and the development of penicillin.

On page 45 of this issue and in future issues as we uncover suitable items, we shall report what we choose to call "Serendipics", a mild distortion of Walpole's original coinage. In our usage, we shall always leave the interpretation of the usefulness of the development or idea to the sagacity of the reader.

Harold G. Buchbinder
EDITOR

Letter

Tailor Made Nerve

Davenport, Iowa

. . . would like to congratulate you on . . . (1) the tremendous nerve your organization must possess to place a magazine on the market when such a flood of literature already exists (2) getting straight to the point . . . by defining "The Ideal Research Executive." (3) . . . the most important thing you have accomplished . . . tailor made a magazine for the busy R/E man who formerly had to wade through tons of material to get to the articles of interest to his particular profession . . .

GILBERT BROWN
Engineer in Charge Ultrasonic Research
PIONEER-CENTRAL
DIVISION BENDIX AVIATION CORP.

Aesthetic Research

Springfield, Mass.

I have reviewed with considerable interest the first issue . . . I certainly feel that you . . . have done an excellent job and will fulfill the urgent need on the part of managers of research development and design to be kept abreast of the most recent developments in this field.

In reviewing your prospectus, I note the absence of any mention of research in the field of product styling and aesthetics.

Aesthetic research, i.e. the investigation of form, texture and product appeal to the consumer, is a relatively new field. It is, however, one which is witnessing a rapid growth and which is becoming of tremendous importance to the producer of consumer products.

The Industrial Designer, the man who puts into practice the results of such research, is fast becoming an important factor in the American market place. It is he who, in combination with the engineer, coordinates technological advances in science and engineering with knowledge gleaned from a study of human engineering (Biomechanics) and adds to it, that plus factor, incapable of definition, but which provides the finished products with the appeal necessary to stimulate the consumer into a purchase.

This man should read your magazine, and your magazine should devote, I believe, some of its editorial content to these activities . . .

LUIGI A. CONTINI
Asst. Mgr. in Charge of Design Research
Market Development Dept.
MONSANTO CHEMICAL CO.

Filing Problem

Nutley, N.J.

. . . congratulations on the first issue . . . I feel it will fill a definite need in research and development organizations such as ours.

Being confronted . . . with the necessity for convincing management of the necessity for more and better standards in such an organization, I was particularly gratified by seeing the excellent article by Dr. Gaillard . . . I am taking particular pains to see that this article is brought to the attention of our top level management . . .

I have only one criticism of your initial issue—the "non-standard" size of 9¾ x 12¾ inches. I assume that you have conducted research leading to the conclusion that this size has certain advantages . . . Judging by the first issue, R & E will contain items such as Dr. Gaillard's article which will be of permanent value to a great many people and would find its way into standard file equipment if it were not oversize . . .

Incidentally, I would, of course, be extremely interested in receiving my own personal copy of each issue of your magazine.

H. R. TERHUNE
Manager Standards and Components Dept.
FEDERAL TELECOMMUNICATION LABS.

Oversized

Whiting, Indiana

I was very glad to receive the first issue of your new magazine and I read it with a great deal of interest. I should like to be placed on your permanent mailing list.

I have one suggestion, which may or may not be helpful: the very nature of your magazine as outlined in the "Prospectus" indicates that it will contain a number of articles worthy of clipping and retaining in personal files for ready future reference. The 9¾ x 12¾-inch page, however, is too large to fit an ordinary file folder. A reduction in size might be worthy of consideration.

A. P. LIEN
Assistant Division Director
Chemical Products Division

(Considerable thought went into the determination of our page size. Major factors that coalesced our thinking were easier reading because of larger type and layout possibilities. These advantages more than outweigh filing problems—Ed.)

Stimulating

Cleveland, Ohio

I have just finished reading the first issue . . . and immediately sat down to write a congratulatory note. I found R & E to be intensely interesting and excitingly stimulating.

You have set a high standard with the first issue and I sincerely hope that you will be able to keep up the pace. I shall look forward to successive editions with anticipation.

Congratulations and the best of luck.

W. H. NICHOLS
Vice President
RAND DEVELOPMENT CORPORATION

Congrats

Holyoke, Ma

Have just read your first issue . . . it's a fi job . . . Particularly enjoyed reading: "Fra work for Engineer Development" and "Ve High Pressures" due to their closeness writer's personal interests.

We would appreciate being placed on t mailing list to receive future copies of R & regularly. . . . This copy will be made avai able to our entire engineering staff throu our Works Technical Library.

P. J. EQUI
Eng. Training Coordinat
WORTHINGTON CORP.

Helpful

Hamilton, Oh

. . . From this first issue we have alrea learned techniques that may be helpful to in the function of high pressure pumps a controls through the articles "Very Hi Pressures" and "Ideal Components for Contr Systems." We compliment you on bringi about a publication and establishing a mediu for the interchange of scientific knowledge.

We shall deeply appreciate your placing on your subscription list.

JOHN T. MARSHAL
Chief Engineer
HAMILTON DIVISION
BENDIX AVIATION CORPORATION

Impressed

Centralia, M

Please accept my congratulations on yo first issue . . . and my best wishes for a su cessful future.

I was especially impressed by the followi articles dealing with management and ope ating problems: "The Ideal Research Exe tive"; "Framework for Engineer Develo ment"; "Standards—Platforms of Progress "R/X For A Top Notch R/D Boss."

I am confident that your publication w serve a real need for information on manag ment of technical operations, research a development, and engineering . . .

R. W. KUNKLE
Engineering Manag
A. B. CHANCE COMPANY

Copy Circulated

Endicott, N.

. . . your new magazine was read with gre interest and will be a helpful contribution development engineering. The article by D John Gaillard . . . is an excellent presentati of both a significant problem and an easi understood answer. The application of stan ards in development areas of industry is a ne and challenging approach to take advanta

continued on page

continued from page 6

of standards as a necessary tool for the engineer. My copy is being circulated with interest among the staff members of my division, and I am sure several subscription requests will be forthcoming.

W. G. BAIRD
Project Engineer
INTERNATIONAL BUSINESS MACHINES CORP.

Two Ideas

New York, N.Y.

. . . I like the idea of such a journal. It is too much to hope that it would or could replace the myriad informational services that are so time-consuming and so seldom rewarding, but that have to be plowed through for the nugget that might be there; but it could replace some of that, and maybe a lot of it.

I liked the first issue. I got two ideas out of it, both worthwhile.

H. L. LOGAN
Vice President Research
HOLOPHANE CO., INC.

Article Suggestions

Syracuse, N. Y.

. . . I would like to offer the following comments. The layout, printing, paper and general format appear very good. Your basic principle of a publication covering the methods of Research and Engineering seems very worthwhile. If I understand your primary purpose correctly, however, the technical article entitled An Ideal Component for Control Systems, the Book Review of Technical Books and Research Reports Section would go better in one of the existing technical magazines. Instead of the detail technical articles I believe you should confine your copy to general methods and procedures.

A few subjects I would like covered. . .

1. Methods of recording engineering data; that is, notebooks as compared to loose leaf sheets, progress reports, etc. This article could elaborate on the various advantages and disadvantages of the different methods and give several examples of the systems used by some of the larger companies.

2. Methods of model construction, machine shop procedures, etc. as applied to engineering and research sections. This article could cover the advantages of a central model shop compared with individual machine shops and machinists for small engineering groups.

3. A central loan type instrument or tool section for a large engineering and research group as compared to individually owned and assigned instruments and tools. This could cover the advantages and disadvantages and examples of these two basic methods. It would include a discussion of a central instrument and tool development group as compared to individual group construction of special tools, instruments and measuring equipment.

4. Central secretarial, stenographic and messenger service sections as compared with individual units. This would cover examples and once again advantages and disadvantages of the two general basic systems. . .

FRED J. LINGEL
Materials & Processes Lab
GENERAL ELECTRIC COMPANY

GENERAL COMMENTS

Corning, New York

. . . greatly interested in the the first issue . . . Would you . . . place me on your mailing list?

H. R. KIEHL
Associate Director of Research
CORNING GLASS WORKS

Ft. Monmouth, N.J.

. . . was quite impressed by the quality of articles pertaining to research and engineering management.

S. E. PETRILLO
Director of Engineering
SIGNAL CORPS ENGINEERING LABORATORIES

Laurel, Miss.

. . . have just received the first issue and wish to compliment you on the magazine.

ROBERT M. BOEHM
Director of Research
MASONITE CORPORATION

Cleveland, Ohio

. . . have just received . . . the first issue . . . and have happily noted the pertinence of several articles to our work here.

E. C. HUGHES
Chief Chemical & Physical Research Division
THE STANDARD OIL COMPANY

Culver City, Calif.

. . . I would like to express my interest. If the same quality of this month's material is maintained in succeeding issues, it promises to be a very informative publication.

A. V. HAEFF
Vice President & Director of Research
HUGHES AIRCRAFT COMPANY

Boundbrook, N.J.

. . . was very much impressed with the material contained . . . in your first issue . . .

JOSEPH H. PADEN
Director, Research Div. Bound Brook Labs.
AMERICAN CYANAMID COMPANY

Dover, N.J.

. . . have found its contents extremely interesting and very pertinent to the problem of management and engineering . . .

GERRY WEINGARTEN
Chief Applied Chem. Unit
PICATINNY ARSENAL

Laconia, N.H.

. . . have just looked through a loaned copy of the new publication . . . should appreciate being included in the group of men in charge of research, development and design so that I may receive future issues.

WILLIAM O. MC MILLAN
Vice President Development Engineering
SCOTT & WILLIAMS, INC.

Brea, Calif.

. . . would appreciate receiving your new publication regularly . . .

DR. REX E. LIDOV
Research Associate
BREA CHEMICALS, INC.

Midland, Mic

. . . the first publication I have seen which directed towards those who manage researc

M. R. KINTER
Organic Chemist High Pressure La
THE DOW CHEMICAL COMPANY

Boston, Mas

. . . very gratifying to have a publication wi such a refreshing approach to the broad sub ject of research and engineering.

REGINALD HARTLE
Chief, Standards Grou
LABORATORY FOR ELECTRONICS, INC.

Skokie, Il

. . . have read with a great deal of interest m first copy . . . will appreciate having my nam kept on your circulation list.

WILLIAM C. KNOPF
Manager Skokie Laborator
INTERNATIONAL MINERAL & CHEMICAL COR PORATION

Richmond, Va

. . . holds promise of being a very valuabl publication which will fill a very definite nee among research and development administra tors.

ROBERT N. DU PUIS
Vice President-Researc
PHILIP MORRIS & CO. LTD., INC.

Hollywood, Cali

. . . received first copy and am very favorabl impressed . . . There is real need for a maga zine such as this . . .

MAURICE NEELES
Director of Diversification and Researc Development
TECHNICOLOR MOTION PICTURE CORP.

St. Paul, Minn

. . . would appreciate having my name adde to your mailing list as this publication woul prove beneficial to me.

J. R. FAVORITE
Technical Director Duplicating Products Di
MINNESOTA MINING & MANUFACTURING CO.

Rumford, Main

. . . have been very much impressed with th first issue . . . and would like to continue re ceiving this magazine.

P. M. SCHAFFRAT
Director of Researc
OXFORD PAPER COMPANY

West Hartford, Con

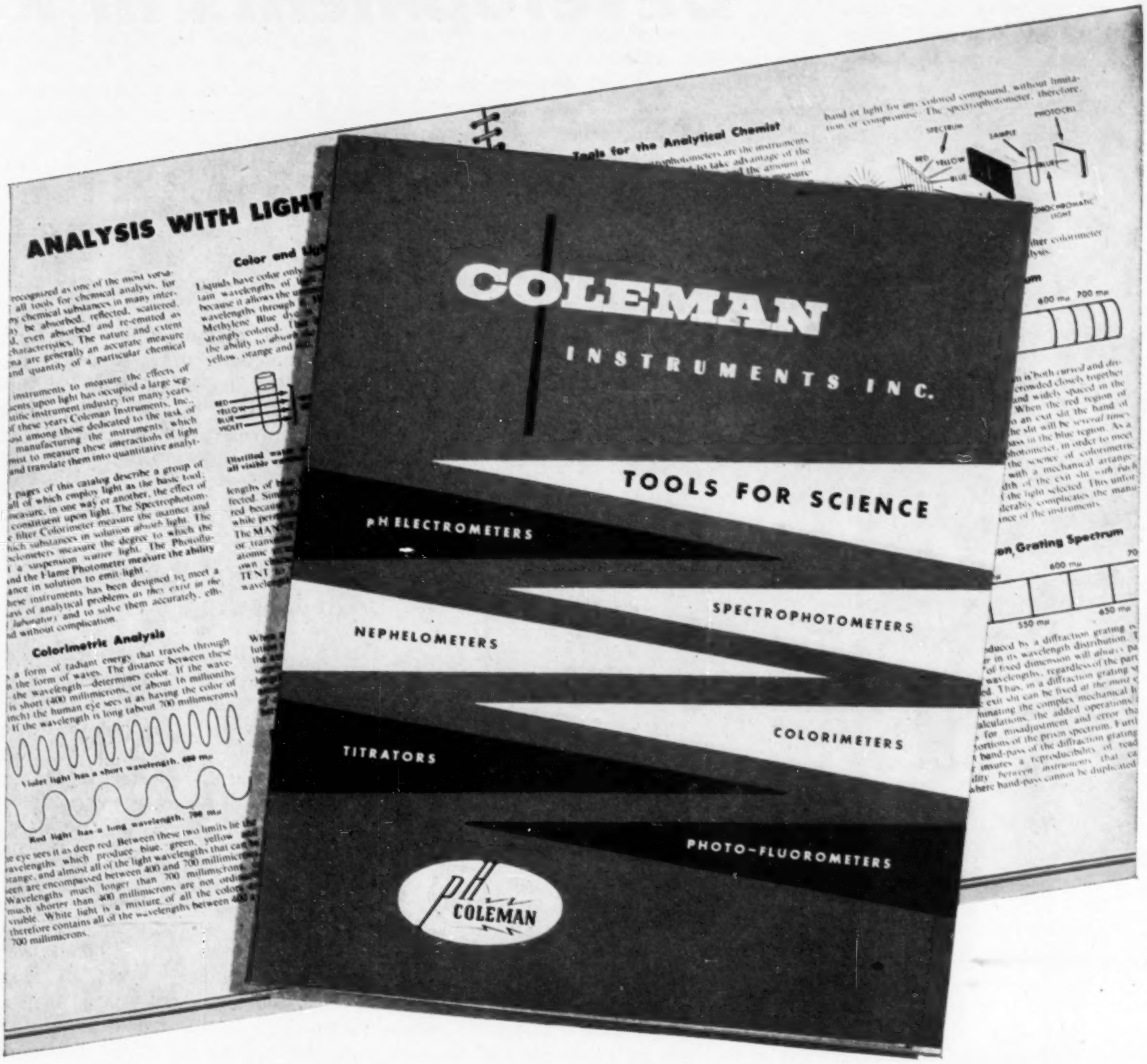
. . . have just had my attention called to th first issue . . . wish to say it looks like a fin start.

ALBERT M. DEXTER
Manager Gage Research & Developme
PRATT & WHITNEY

Hamilton, Ontar

. . . please add me to your mailing list. . .

R. O. MORSE
Manager Research & Development La
WESTINGHOUSE COMPANY



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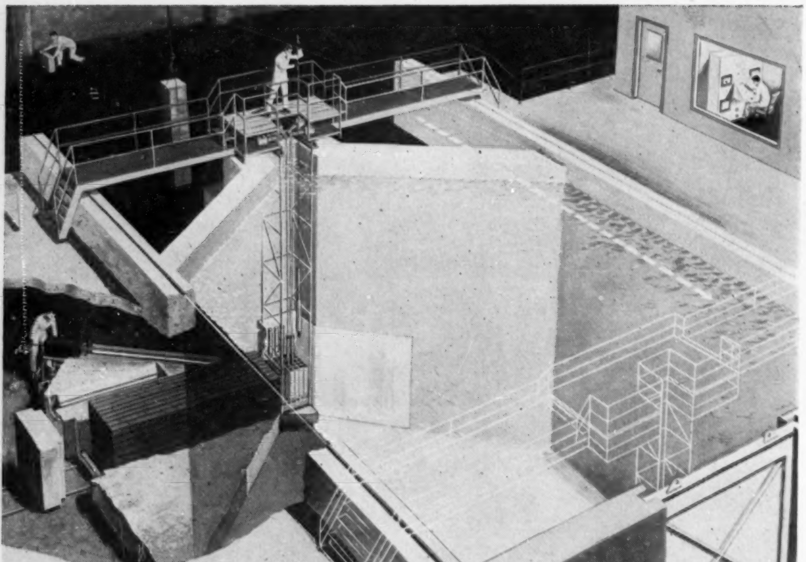
Coleman Instruments, Inc. Dept. F, 318 Madison St., Maywood, Ill.

Developments in R/E



Proposed nuclear reactor will be of the "swimming pool" type using uranium fuel surrounded by water serving as a moderator, cooler and shield. In addition to providing large-scale amounts of neutrons and gamma rays, it will also be a source of radio–isotopes.

Eight Companies Plan to Build Nuclear Research Lab

NEW YORK, N.Y.—Eight leading industrial companies plan to build and operate in the New York area the first nuclear reactor to be owned and operated by private industry for research in industrial and humanitarian fields.

The companies participating in the formulation of the plans include AMF Atomics, Inc., American Tobacco Co., Continental Can Co., Corning Glass Works, International Nickel Co., Chas. Pfizer and Co., Inc., Socony Mobil Oil Co., Inc., and the U. S. Rubber Company. Other companies are expected to announce their participation shortly.

The Industrial Reactor Laboratories, as the facility will be called, will be located on a 250 acre tract within commuting distance of New York. Options have already been taken on two sites in New Jersey and New York within 50 miles of the city. It will cost between $1,500,000 and $2,000,000. Final selection of the site is subject to clearance of the Atomic Energy Commission from which the reactor's fissionable fuel will be obtained on a lease basis.

Operation of the Laboratories, which are expected to be ready for use in the fall of '56, will be directed by a leading university, according to policy set down by a Board of Directors to be made up of representatives of participating companies. Ownership of the Laboratories will be vested in a corporation, each company having an equal stock interest. With this new facility, inquiry into the effects of radiation upon basic materials handled by these major concerns will be speeded up. Part of the reactor's operating time will be offered for medical research.

Each participating company will be free to perform its own industrial research under conditions that will protect its own discoveries. Purpose of their research will be the development of new products, or new methods in their manufacture that will be of widespread consumer benefit. Participating companies are expected to be from the metals, petroleum, electronic, rubber, glass, plastics, industrial and agricultural chemicals, pharmaceuticals, machinery, tobacco, food packaging and other industries.

General Walter Bedell Smith, chairman of the Board and president of AMF Atomics Inc. stated: "The existence and operation of the Industrial Reactor Laboratories will be a major step toward bringing to light currently unknown uses of the peaceful atom."

Plant Food Research On Upswing

STATE COLLEGE, PA.—Research in the field of fertilizer production and manufacturing techniques is going ahead to an extent never before dreamed about, J. Albert Woods, president of Commercial Solvents Corp., reported to the American Society of Agronomy at the 75th Anniversary Celebration of the Jordan Soil Fertility Plots at Pennsylvania State University.

The search is on for new and improved methods of granulation, a lower cost process for the production of nitric acid, the further development of liquid fertilizers, improved methods of nitrogen fixation, the role that trace elements may play in the utilization of the major elements, and the lowering of the cost of all raw materials, which only an improved technology can tend to bring about.

Ammonium nitrate, anhydrous ammonia and nitrogen solutions which were almost unknown as fertilizer nitrogen carriers 20 years ago, dominate the nitrogen industry in this country today, Woods said.

He pointed out that plant food research in the last 15 years has helped bring about a fourfold increase in the use of fertilizers—a growth twice as great as for the 30 years prior to that time.

He believes that the fertilizer industry will continue the same kind of intensive and active research that has spearheaded this amazing progress because plant food research will be accelerated and expanded in the years ahead. We can expect greater production by this industry, higher analysis fertilizers and, in general, plant foods which will yield larger and better quality crops.

AEC Invites Proposal For Reactor Construction

WASHINGTON, D. C.—The Atomic Energy Commission has asked industrial firms interested in designing and fabricating a small nuclear reactor for testing reactor cores to submit proposals for construction.

The reactor, to be built at the National Reactor Testing Station in Idaho, will be a high pressure water-moderated and water-cooled type. Core tests will be conducted in the reactor under severe operating conditions as part of the Commission's program for determining safe limits and developing reactor designs with maximum safety characteristics.

Cost of such a reactor is estimated between $250,000 and $500,000. Firms indicating interest in the project to the AEC's Reactor Development Division will be given an opportunity to submit proposals late in September 1955. Delivery will be scheduled for mid-1956.

Monsanto Intensifies Plastics Research

SPRINGFIELD, MASS.—Monsanto Chemical Company's Plastics Division opened the laboratories of a new research building that will permit sharp increases in every area of research. Harold W. Mohrman, director of research for the division, said that the new three-story building, doubling the division's research facilities, contains equipment for the "full spectrum" of research—exploratory research, process and product development, end-use research, integrated research and technical service.

One area of emphasis will be in application engineering studies: investigations of structural properties, fire or burning characteristics, weather resistance and end-use temperatures. End-use research is organized to develop applications by industry groups, such as textiles, surface coatings, foundry resins, paper, food packaging, phonograph records and automotive safety glass.

Basic research for the immediate future will include laboratory study of polymerization mechanisms, poylmer structure and exploratory work on new type of resins.

Monsanto has formed a structural plastics engineering group in its Plastics Division. A. W. Low, director of engineering said, "The new group, believed to be the first such specialized unit in the plastics industry is the result of a year-long exploration by the division of ways to fill the need for authoritative professional engineering information on the use of plastics in construction.

"We believe the plastics industry has the opportunity and the obligation to take the lead—both internally and externally—in fostering the use of plastics as construction materials according to sound engineering principles and, at the same time, to prevent their misapplication," he said.

In addition to coordinating structural plastics studies within Monsanto, the new group's functions will include developing, correlating and publishing structural plastics engineering data and participating in technical and trade society activities and joint testing programs. Construction and evaluation of plastic structural component prototypes also will be undertaken.

Soup-Can Gas Generator Produces 850 Jet HP

CINCINNATI, OHIO—A gas generator hardly bigger than a can of soup, yet capable of producing about 850 jet horsepower, has been developed by the General Electric Company's Aircraft Gas Turbine Development Department.

D. Cochran, manager of the Department, said the gas generator was developed for application to guided missile propulsion systems, but that it is ideal for many applications where a portable, lightweight and reliable source of energy is required.

Using no moving parts, the gas generator converts liquid hydrogen peroxide into a high pressure, high temperature gas stream of free oxygen and steam. The jet may then be directed against a turbine wheel and the rotative power thus generated may be used in the same manner as any turbine–generated power.

Possible industrial applications of the gas generator include use as a source of energy for rotating machinery, as a thrust simulating device for static tests of airplane or missile models, or as a quick and reliable source of steam.

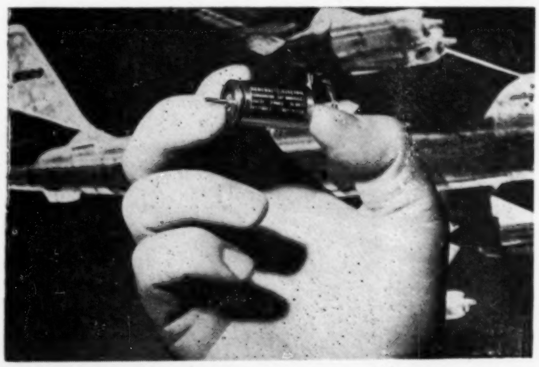
Thumb-Size Motor

No larger than a man's thumb, a little motor originally designed for use in the gyro component of G-E's MA-1 compass-controlled directional gyro-compass system has been released for other applications.

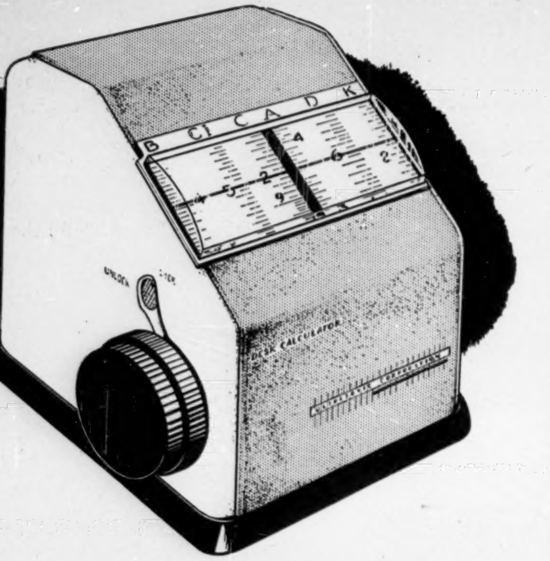
Rated at 26 volts and weighing just 1.2 ounces, it is ⅝″ in diameter and 1.2″ long. Its no-load speed is 21,000 RPM, and it has exceptionally high acceleration, stall torque and efficiency for a motor of its size and type.

It is designed to withstand ambient temperatures in the range of —55° to +90°C when operated as a control motor and is built to provide satisfactory performance at altitudes up to 60,000 feet. This two-phase, low inertia servo motor may be used in a wide variety of circuits to make possible accurate null-method measurements as well as to provide the power required to initiate control.

Weighing less than 3½ pounds, and only about 4″ long by 3 in diameter, the gas generator produces about 850 jet horsepower in its designed guided missile application. Jet hp from the same unit has been varied from as little as 50 to about 1800 by simply adjusting the incoming liquid flow rate.



...elieved to be the smallest ...o'or currently used on air-...raft. G-E engineers predict ... designers of instruments ...d servo systems will find it ...n be adapted to many other ...ses.



Manually-operated three hundred inch slide rule has its scales engraved on a pair of Neg'ator tapes (prestressed steel bands that are unwound from a coil by a constant force) with a precision of one part in ten thousand. Scales permit a calculation of the form

$$x = A \sin \theta \cos^2 \theta$$

to be performed with five place accuracy.

Telephone-Size Desk Calculator Contains 25 Ft Slide Rule

CAMBRIDGE, MASS. — Accurate slide rule calculations of trigonometric and other complex functions involving powers and roots can now be obtained with typical slide rule procedures. Ultrasonic Corporation expanded the conventional scales to lengths of 25 ft and then reduced the overall size by engraving the expanded scales on drum-mounted constant-torque steel tapes.

The idea of increasing the accuracy of the slide rule scales was an outgrowth of the design of the zone wind computer, one of seven computers which make up the U.S. Signal Corps' Rawin Ballistics computer, a manually operated, mechanically driven unit containing a number of expanded scales engraved on constant-torque tapes developed by the Hunter Spring Company.

Ultrasonic is considering production of the desk calculator utilizing expanded scales of this type. The company feels that both the manually and the electrically operated models of this device can be manufactured to sell at prices considerably below those of the conventional digital-entry desk calculators. The device can replace digital-entry calculators requiring the use of specially outlined procedures when applied to engineering calculations of the type that can be quickly performed on the slide rule. Costs will be significantly below that of digital calculators.

Stockpile of Unused Knowledge Diminishing

MADISON, WISC.—The national scientific ace-in-the-hole—a stockpile of unused knowledge that is far ahead of its time—is faded and worn and only years of basic research will restore it. Conrad A. Elvehjem, dean of the graduate school at the University of Wisconsin and discoverer that pellagra is caused by a Vitamin B deficiency, said that the nation's ratio of basic to applied knowledge is far behind what it was before World War II.

He added that basic research scientists are no longer ahead of applied scientists, engineers and doctors who put new facts to practical use. Before the last war our knowledge of many things—the atom, for example—was far ahead of our knowledge of what we could do with such knowledge. Today no such hidden reserve of knowledge exists.

We can build another bulwark of "useless" facts only by increasing the ratio of basic to applied research, one of the purposes of universities and of research sponsored by such organizations as the National Science Foundation, Elvehjem said.

Elvehjem spoke to many of the nation's leading scientists and mathematicians attending a conference at Wisconsin on the use of electronic calculating machines to solve problems in all fields of research.

He said the major problem for the nation's administrators is how fast we want to expand research. "We must have many years of great activity in basic research in order to restock our shelves of basic knowledge." Elvehjem added that well-equipped and well-manned computing laboratories are an important adjunct to the scientific work of any large research center, and said that there exists a general feeling that more students should be steered into the study of mathematics and computer operation.

Radioactive Waste May Provide Auxiliary Power Through Atomic Batteries

NEW YORK, N.Y. — Radioactive waste from fission nuclear reactors used for power production may in the future be employed in atomic batteries to provide an auxiliary power source, according to Dr. E. G. Linder, research scientist of the Radio Corporation of America.

In a review of research on atomic batteries and other direct conversion devices at the International Conference on Peaceful Uses of Atomic Energy meeting in Geneva, Dr. Linder cited estimates to the effect that if all electrical power consumed today in the United States were produced by nuclear reactors, the radioactive waste material left over from this process would generate radioactive energy at the rate of 400,000,000 watts, "which represents only a few hundredths of 1 percent of the energy consumed in the country.

"This figure is further reduced because the radioactive energy could not be converted into electrical energy with more than a few percent efficiency," he said. However, he added: "In spite of these factors, the power which might be available is still a substantial amount, especially if it is compared to the total power supplied in the United States from the annual production of batteries, which is approximately 2,000,000 watts. . . .

"It is evident . . . that fission products cannot be considered as a possible principal source of power; in fact, their availability in large quantities is contingent upon the use of reactors as the principal source of commercial electric power. They should be considered rather as a possible auxiliary source of considerable magnitude, with a possible maximum roughly equivalent to that produced by batteries at the present time."

Dr. Linder's paper was prepared in collaboration with Paul Rappaport and J. J. Loferski, of the staff of the David Sarnoff Research Center of RCA at Princeton, N. J. The three were responsible for development of the experimental atomic battery demonstrated in January, 1954.

In the paper, the scientists stated that commercial radioactive power sources such as the atomic battery can be considered only for very low power applications until there becomes available a radioactive material of low cost, low quantum energy and a suitable half-life. In the absence of such an ideal material, the possible applications lie only in the microwatt range of such devices as radiation meters, timing circuits and transistorized equipment.

However, they said, "it is to be expected that the practical energy level for commercial applications will gradually rise as radioactive material becomes plentiful."

New Math Formulas Speed Lens Design

ROCHESTER, N.Y.—The first complete analysis of an optical image, a technique that will permit speedier design of better lenses, has been achieved in Kodak Research Laboratories through the development of new mathematical formulas. The scientific short-cut devised by Dr. Max Herzberger, who heads Kodak's optical research, is essentially a way of analyzing the optical image and considering it as a superimposition of five simple types of images. He accomplished this by finding five simple types of image errors, from which he can synthesize the most complex optical image. As part of his research he also simplified a practical system of tracing skew or slanting rays of light through a lens so it can be used in routine calculations.

Until now, lens designers, using computing machines, have laboriously traced rays of light through a lens system during the design stage. Dr. Herzberger has reduced this to the tracing of only nine rays; by projection with his mathematics, this is equivalent to tracing perhaps 1,000 rays.

With his new technique, also, the Kodak scientist computes for the entire area of the lens. Previously lens designers traced light only through a cross-section of a lens system.

To achieve his complete analysis, something sought by scientific workers during a century of optics research, Dr. Herzberger first learned how to classify image errors for full aperture and for an extended field. Types of errors describe degrees of symmetry or asymmetry in the image. They also describe the amount of deviation in all directions.

The method permits the designer to visualize how errors are balanced in a given system and thus guides the designer in his aim, to obtain a better lens.

Faster Films In Future

Photographic film speeds may increase as much as 100 times in the next 75 years, according to Donald McMaster, vice-president and general manager of the Eastman Kodak Company. McMaster stated that in the 115 years since the invention of the daguerreotype the speed of the photographic system has already been increased about one million times. In predicting speeds which photographic materials will attain in the future, he pointed out that even the highspeed films currently available are not the ultimate. On the basis of recent discoveries in emulsion research, photographic scientists believe it may eventually be possible to increase film speed at least another 100 times.

McMaster also made these additional predictions on future developments in the field of photography: film processing—both black-and-white and color—will become simpler and quicker; color picture quality will continue to improve and color film speeds will be faster; medical motion picture radiography will become widely used as a diagnostic tool for doctors.

Estimates are based on developments currently in the industrial research laboratories, on photographic needs and wants and on present directions of science and technology.

Pointing out that the photographic industry has grown at a faster rate than industry as a whole, the Kodak executive said, "I don't think it is unreasonable to expect that photography will continue to expand faster as our economy expands, since its uses within this expanding economy will increase, and other new uses will be found."

Du Pont Develops New Family Of Electrical Insulating Materials

WILMINGTON, DELA.—A new family of electrical insulation materials highly resistant to solvents, oils and refrigerants is being produced in pilot plant quantities by the Du Pont Company Fabrics and Finishes Department. For the first time it is now possible to use potentially inexpensive and chemically identical insulating materials throughout a motor.

"Lecton" acrylic resin wire enamel, glass fabrics coated with the resin and laminates of the coated glass fabric will withstand temperatures for extended periods above the minimum required for Class B insulation (130°C.). They can be used intermittently at temperatures up to 150°C. Dielectric properties of these acrylic materials are essentially unaffected by humidity.

At present in the pilot plant stage, glass fabric coated with "Lecton" is being offered in experimental quantities in a 3 mil construction, 38 inches in width, to manufacturers of electrical equipment at $1.41 a yard. It is expected that the cost will be substantially reduced when demand justifies production in commercial quantities.

"Lecton" enamel can be applied to various glass fabric constructions as well as fabrics woven from other materials. Laminates of various thicknesses are available in test quantities for evaluation as slot liners, top sticks (wedges) and coil separators. "Lecton" acrylic resin wire enamel was the first acrylic offered wire manufacturers and since its introduction on a trial basis in 1954, it has aroused considerable interest as the result of tests in fractional horsepower motors.

Engineers' Starting Salaries Still Increasing

CHICAGO, ILL.—Starting salaries for beginning engineers continue to increase at Illinois Institute of Technology, according to figures compiled by Earl C. Kubicek, director of alumni relations and placement. They show that the starting pay of the 1955 June engineering graduate with a bachelor of science degree climbed to $381 per month, as compared to the $363 received by the 1954 June graduate.

The figure is a drop from the all–time high of $383 received by the 1955 January engineering class. But, Kubicek pointed out, the differences in the size of classes and other factors account for the invariably higher starting wage received by mid-year grads. Averages, based on the starting salaries of combined June and January graduating classes at IIT, have increased every year since 1949 when the average was $282 per month, Kubicek said. In 1950 it jumped to $288; 1951, $295; 1952, $328; 1953, $362; 1954, $368, and 1955, $382.

For the first time, starting salaries of specific categories of engineers topped the $400 mark, with 1955 June electrical engineers receiving $416 and metallurgical engineers getting $404.

A year ago electrical engineers received $386, as compared to $390 in January, 1955. Metallurgical engineers received $377 in June, 1954, and $397 in January, 1955.

"One of the more noteworthy trends pointed up by the latest survey is the desire by organizations to secure a greater number of engineering graduates for eventual advancement to managerial and supervisory positions," Kubicek pointed out.

He said the move in that direction was underscored by the increasing demand on the alumni section of the IIT placement office by industry for experienced Illinois Tech engineering alumni for executive positions.

Synthesis of Cytisine Uncovers New Compounds

MADISON, WIS.—Two University of Wisconsin chemists revealed that they are the first to synthesize the extremely poisonous alkaloid, cytisine, a feat which various chemists have been attempting to accomplish since the early 1930's. The chemists are Prof. E. E. Van Tamelen and John Baran, a graduate student in the University of Wisconsin chemistry department.

Cytisine is so poisonous that it is of little practical value, but its synthesis is important because a chemical hurdle in the synthesis of certain types of compounds has now been jumped. Synthesis of similar alkaloids, some of which are useful, probably can now be accomplished. In addition, all of the intermediate compounds obtained at various steps in the synthesis are new to science and can be tested for their usefulness.

Cytisine is a member of a family of alkaloids known as lupinanes. Most lupinanes contain molecules with a unique unsymmetrical, bridged structural system. It was hitherto not possible to synthesize this system; other alkaloids have been synthesized, but never a member of this type. In their synthesis, the chemists begin with a cheap and simple coal-tar product known as alpha-picoline and build cytisine in 11 steps.

Cytisine is found naturally in certain leguminous plants, commonly known as gorse, broom and laburnum. Ancient peoples knew these plants to be extremely poisonous, and this quality was quick to arouse the curiosity of chemists, who isolated the poisonous substance as early as 1865. In the early 1930's, two groups of scientists, one led by H. R. Ing in England, the other by Ernest Spath in Austria, simultaneously worked out the chemical structure of cytisine, showing that it is one of the complex lupinanes.

Since 1930, scientists in various parts of the world are known to have attempted to synthesize the white, crystalline substance. Prof. Van Tamelen and Baran began their work less than two years ago. The two scientists point out that while the work is essentially in the realm of basic research, the knowledge gained undoubtedly will be of value in the synthesis of other related substances, some useful to man.

Fluorine's Reactive Energy Harnessed In Chemical Cutting Tool

HOUSTON, TEXAS — The tremendous energy potential bound up in elemental fluorine and in halogen fluorides now has its first big industrial use. Combining their talents, McCullough Tool Company designers and Pennsylvania Salt Manufacturing Company chemists have come up with a streamlined tool for cutting and perforating steel pipe miles below the surface of the earth.

The chemical is contained in a heavy-walled cylinder equipped with a pressurizing chamber and a firing head with appropriately spaced orifices. The assembly, lowered into an oil well, is positioned accurately and held against powerful thrusts by specially designed latches. Upon electrical impulse through the electronic panel and conductor cable, the chemical is ejected under enormous pressure against the inner pipe wall, which it penetrates in a fraction of a second.

By changing the placing of the openings, the tool makes a clean cut, with none of the objectionable flaring produced by previously used explosive methods. It also perforates a smooth, burrless hole.

The story behind this achievement covers a span of several years of cooperative effort and involves a fruitful union of mechanical design with chemical science. The specific collaborators were McCullough's W. G. Sweetman, Director of Explosive Research, and Pennsalt's John Gall, Henry Miller and Fred Loomis.

Sweetman, seeking to overcome limitations of mechanical, gun and explosive jet tool devices for use in the narrow confines of a well bore, conceived the method of combining the reactive properties of fluorine and its more reactive compounds. He found he could greatly accelerate the rate of release of maximum amounts of energy by the application of pressure and concentrate it at the points to be attacked.

Pennsalt aided him in the selection of the compounds best adapted for his purposes and in the solution of the various problems necessarily associated with packaging, loading, storing and handling of the highly reactive compounds.

The chemical cutter for 2" and 2½" tubing has operated successfully in commercial operations at depths of a few hundred to many thousand feet. In addition, a chemical-cutter for casing has been developed and will be available for commercial use in the near future. Halogen fluoride perforating tools have already been designed which show distinct advantages over present bullet and jet perforators. Research also is being conducted on the development of a tool for drilling wells through extremely hard formations, an operation which is now slow and expensive with diamond bits.

Ferrophosphorus Aggregate Simplifies Atomic Cell Design

CHICAGO, ILL.—Development of ferrophosphorus as an aggregate for concrete used in protective shielding of atomic hot cell installations was disclosed by Victor Chemical Works. The development simplifies the construction of nuclear hot cells, the number of which is rapidly growing as more and more university and industrial research centers move into atomic inspired research and engineering experimentation in many product fields.

Because of the necessity for close supervision of work within a hot cell, both visually and mechanically, the thickness of the protective walls which shield the radio-active materials is of extreme importance. The thinner the wall, the easier the operation. Engineers and scientists thus have been under pressure to develop the greatest possible protection with the thinnest possible walls.

Nearly any dense material, according to Victor engineers, is considered a good absorber of radiation. Many different materials were tested. Ordinary concrete with a density of only 150 pounds per cubic foot proved undesirable because hot cell shielding walls of it would have to be six to eight feet in thickness. Low grade iron ore and other ores such as barytes were tested but the maximum obtainable density was only between 200 and 220 pounds per cubic foot. Scrap steel, shot and steel punchings produced a dense concrete, but segregation in such mixes occurred, seriously affecting the workability of the mix. In some tests rusting was found which caused deterioration in the strength of the finished shield.

Ferrophosphorus, however, produced a density of 290 to 300 pounds per cubic foot and showed excellent workability and no segregation in working, pouring or setting. Being a chemically inert material, the resulting concrete protective shields are insoluble in acids and will not rust, thus bringing about trustworthy and long lived protection from the effects of radiation.

Victor ferrophosphorus, in the original chemical form in which it is produced at the three Victor plants, is crushed and sized to special particle size distribution which permits it to be mixed in standard concrete mixing equipment with water and ordinary Portland cement. The resulting concrete, although twice as heavy as ordinary concrete, is easily workable, transportable and pourable.

Rayonier Builds Research Center

NEW YORK, N.Y.—Rayonier Incorporated will establish a new research center on an 82 acre site at Whippany, N.J. as a further expansion of its scope of research. Dr. Arthur N. Parrett, vice president in charge of research and development, said that the chemical cellulose firm now has its research facilities concentrated at Shelton, Wash., where 150 scientists and technicians are employed in its Olympic Research Division. The New Jersey expansion will further broaden their basic cellulose studies.

Dr. Parrett noted that while development of new and improved cellulose-base fibers, films and plastics has been in progress for many years, intensely accelerated research activity is underway throughout the world. "A new optimism exists that cellulose products derived from wood can be developed on a broad scale to fill large markets yet untouched and meet competition from other synthetic products," he said. Rayonier believes that its expanding research will initiate and contribute to growth in industries interrelated in the production of cellulose products.

Dr. Parrett pointed out that Rayonier's research objectives are to cover the basic technology of chemical cellulose and its conversion to end-products such as tire cord, cellophane and new types of cellulose-base fibers.

New Surge Test For High Voltage Transformers

MILWAUKEE, WISC.—A new test for power transformers, 115 kv and higher switching surge strength, simulates the most severe surges that can occur in normal use and will eliminate the one remaining major unknown factor in transformer insulation strength.

According to Allis-Chalmers engineers, recent improvements in lightning arresters have made it advantageous to purchase lower insulation level transformers for many applications. Reduction of excessive insulation strength without some means of proving the transformer's ability to withstand switching surges is believed to have held back acceptance of these lower strength and lower priced transformers.

Now, in addition to the standard 60-cycle, full wave, chopped wave and steep wave impulse tests, all large high voltage power transformers can be given a 3000 microsecond high frequency surge approximately 25 to 30 percent greater in value than the lightning arrester rating. Thus 330-kv units will be surged at 930 kv.

A-C states that the test is one more step in the establishment of realistic insulation levels for high voltage transformers. The final goal is adequately protected transformers at considerably lower cost.

Extensive Applications Predicted For High-Molecular-Weight Polyethylenes

MAPLE HEIGHTS, OHIO—The next two years may see one of the greatest transformations in structural and fabricated parts with the use of the new polyethylenes.

Volume production of the High Temperature resins should start during 1956. Koppers Company expects to have its Kobuta, Pa. plant in operation this fall and in full production of resin by the Ziegler method in the spring. Also scheduled for spring operation is the South Charleston, W. Va. plant of the Bakelite Company, a division of Union Carbide and Carbon Corp. Du Pont expects production at its Orange, Texas plant during the fall months. Both Du Pont and Bakelite are Ziegler licensees as is Monsanto and several others. At least five companies have been licensed by Phillips.

Dr. J. A. Neumann, president and director of research of Cleveland's American Agile Corporation points to the recently developed polyethylenes and the new plants which will produce them as being indicative of industry's swing to plastic structures.

"What industry has looked for and what is now being produced is a polyethylene with great rigidity which can withstand relatively high temperature and which has high tensile strength. These characteristics have been embodied in the new materials and make it possible to produce structures and fabrications which heretofore were impossible.

"Structures of the older polyethylenes were produced and used by industry successfully, but the applications were limited because of the lower tensile strength and the lack of rigidity and ability to withstand temperatures normally required for standard sterilization," Dr. Neumann said.

Structural Properties Improved

These failings have been rectified when simultaneously and independently the Phillips Petroleum Company and Dr. Karl Ziegler of Germany's Institute for Coal Research evolved processes for the production of a high-molecular-weight polyethylene with the characteristics desired.

Both the Phillips and Ziegler processes can produce the new resins without the very high pressures and temperatures required with the previous polyethylene. Each process uses a different catalyst.

Phillips' product has been called Marlex 50; those produced by the Ziegler method are marketed under trade names selected by the licensees. American Agile differentiates between its converted resins by calling the older material Agilene LT (low temperature, low tensile) and Agilene HT (high temperature, high tensile).

Tensile strength of the HT is 6000 p.s.i. as with the maximum strength of one-third of that for the LT. The former can withstand continuous temperatures of 250°F. while LT cannot be used continuously above 170°F. and will soften at 220°F.

While the emphasis has always been placed on the high temperatures the materials will withstand, it should also be noted that the HT will not become embrittled at —170°F. while LT does embrittle at —60°F.

Rigidity, an important factor in structural uses, reveals that the HT stiffness modulus has gone to 150,000 p.s.i. for the HT, while that of the LT material has registered 30,000 p.s.i.

Such comparison figures were indicated in all the other tests made between the two types of polyethylene. For example, pipe burst strength of the new material is three to four times greater than that of the LT, and the same ratio is evident when deformation tests under pressure are conducted. Again the ratio is evident for gas and vapor transmission of the materials. Stress crack resistance is greater as is chemical resistance. Elongation tests on HT have run as high as 120%.

"Actually, the range of the HT is unlimited because we have indications that its temperature range may even approach 500°F., although our tests are not yet completed," Dr. Neumann said. "When we took the LT and subjected it to high energy irradiation, we were able to increase its melting point and its tensile strength and generally heighten all its other characteristics. We presently are making similar tests with the HT and so far have every indication that its tensile strength, elongation and temperature resistance will be increased. Stress cracking is completely eliminated.

"One material will not supplant the others. Rather each will lend itself to the special job to be done. Actually, the limit of the products will be based on the limit of our own imaginations," he continued. "Because of the lighter weight and greater rigidity offered by the HT over the LT, we can now build even larger and stronger structures than we have before. What limit we will have with the irradiated HT remains to be seen.

"Comparatively, polyethylene is still an infant, but its impact on industry will be vast in the next two years. I'd like to borrow an old expression 'keep your eye on it' because it will become a most important fabricating material," Dr. Neumann concluded.

Cemented Oxide-Base Cutting Tool Perfected

DETROIT, MICH.—Successful initial development of a cemented oxide-base cutting tool material is reported by G-E Carboloy Department. Still in laboratory stages, it represents Carboloy's endeavor to keep pace with high speed machines currently under development by the machine tool industry.

Lab tests of the new tool material, according to Carboloy engineers, indicate it provides good tool life at speeds of 200 feet per minute. At a feed of 0.005-inch and depth of cut of 0.100-inch at that speed, the tool lasts 27 minutes in machining 1045 steel, annealed to 170 Brinell.

The new cutting tool under development since 1951, is made entirely of inexpensive materials, a factor which may possibly help lower tooling costs. Present cutting tools include such materials as tantalum, tungsten and cobalt, materials which are in relatively short supply, especially during times of emergency.

Carboloy engineers point out that the new laboratory developed material is brittle, more susceptible to cracking than carbides and includes properties which must be thoroughly understood by the tool designer to take advantage of its capabilities. They also pointed out that if the new tool material can be successfully field tested after leaving the laboratory, it may extend finishing ranges in machining in areas beyond those now used. The new material will supplement carbides, much in the same way carbides supplemented high speed cutting tools about 15 years ago.

Gas Density Balance Uses Null Principle

SOUTH PASADENA, CALIF.—A new gas density measures the density of a sample gas by a unique null balance principle. A small dumbbell is supported on a horizontal quartz fiber. One ball of the dumbbell is punctured so that it will not experience buoyancy effects. The other ball tends to rise or dip as the density of the gas increases or decreases. Thus, the dumbbell creates a rotational force about the quartz fiber as it responds to density changes. The magnitude of this force is proportional to the density of the sample gas.

The dumbbell is metal coated to make it conductive and is held in place by an electrostatic force established with adjacent electrodes which are held at a fixed potential. When the dumbbell rotates, it is restored to its null position by applying the proper electrostatic potential to its surface. The magnitude of the balancing potential necessary is proportional to the density of the sample. This article is marketed by Arnold O. Beckman, Inc.

Materials for the Future

GE's New $5 Million Research Facility Will Concentrate on Metals and Ceramics.

SCHENECTADY, N.Y.—"We still don't know why Alnico makes as good a magnet as it does. We know what it does but not why it does it. And we're unhappy when we make a product without understanding everything about it." This comment by J. C. Holloman, manager of GE's Metallurgy and Ceramics Research Department, reflects an important set of attitudes applied in GE's metallurgy and ceramics research. "We do not set out to develop a specific product or process; we study the behavior of metals and ceramics. The result is inevitably new products and processes of broad industrial application."

Dr. Holloman listed 5 objectives of the new research laboratory at The Knolls:

1. To analyze areas of most critical need for materials and processes.
2. To find out what knowledge is needed to solve problems in these areas.
3. To study existing materials and obtain a better understanding of their properties and processes.
4. To apply a better understanding of the "hows and whys" to the development of new materials and processes for the improvement of existing products and the development of new ones.
5. To operate pilot plants and obtain economic data in the development of new processes for new businesses.

According to Dr. Holloman, the ever-increasing diversity of the Company's needs has necessitated the expansion of the facilities with which these objectives were accomplished in the past.

Factory-Size Laboratory for Factory-Size Research

The new building with more than 75,000 square feet of floor space seems more like a factory than a laboratory. Since ideas for new materials and processes frequently come from the "pencil and paper" and "test tube" work done in the basic research areas, many of the things the Company's operating components must know before they can take advantage of these new materials and processes can be learned only by trying them on a scale approaching actual industrial conditions. Thus, a building capable of doing this necessarily must be nearly factory size.

However, there is an obvious difference between this facility and a factory. Here the standard equipment as well as the special equipment is operated under laboratory conditions, with emphasis on measurement and control, and freedom from production schedules.

These pilot operations also must be of a transitory nature, the scientists explain. Ideas do not come to the new building to stay—they are either forwarded on for actual use or sent back to the basic research scientists for further investigation. Then the building must be readily adaptable to the next project.

The new Metals and Ceramics Building, therefore, has an internal structure like an "erector set", permitting quick assembly and easy alteration as a process is developed and perfected. Thousands of bolting holes, aligned throughout the building from floor to roof provide the required versatility. Huge traveling cranes can lift new structural members into place and move heavy apparatus into more convenient locations, all on surprisingly short notice.

Power supplies and service facilities have been distributed on a "modular" arrangement to permit flexibility. Services available on a "turn the handle" basis include compressed air, high and low pressure steam, city gas, nitrogen, oxygen, standard hydrogen, dried hydrogen (—90° dew point), rough vacuum, distilled water, cooling water and hot and cold tap water.

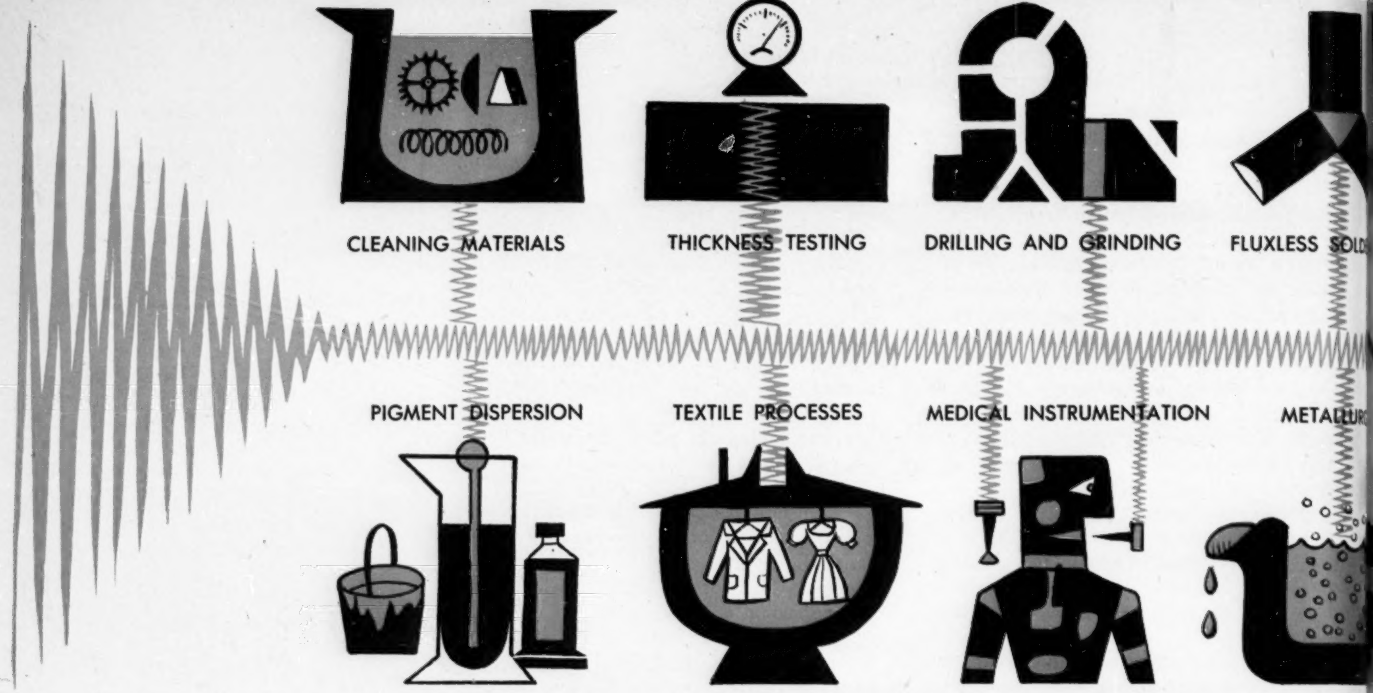
Scientists Helped Design Equipment

Research Laboratory personnel collaborated closely with machine designers to obtain equipment capable of performing the desired "conventional" operations with uncommonly strong "unconventional" material. The 10–inch and 16–inch rod mills are examples of specially-designed equipment. They deform super-strong alloys by performing their operations very rapidly. Pieces of metal initially at a very high temperature are thus reduced to final size before they cool to a temperature where the extreme strength properties are realized. One reduction mill, so new it is still unknown to many metallurgists, has been installed at the new building. Called a "planetary mill" because of the unique arrangement of rolls, it is capable of reducing inch-thick slabs of metal to a one-eighth-inch ribbon in one quick operation.

Researchers Have Full Responsibility

Each of the operations of the processes laboratory is headed by a member of the technical staff, who is assisted by metal-processors trained in skilled operations and by laboratory assistants who follow and guide the work. This organizational arrangement places the responsibility for the work squarely on the shoulders of the scientists, and thus guarantees that the most comprehensive technical understanding is applied to every project.

Metallurgy and Ceramics Research is one of four research departments at G-E Research Laboratory; the others are Chemistry, General Physics and Electron Physics.



ULTRASONICS

The past few years have witnessed the extraordinarily rapid growth of a new industry entirely devoted to making practical use of mechanical vibrations occurring at frequencies above the audible range. The term "ultrasonics" best describes the acoustical boundaries involved.

The techniques of testing and processing materials by ultrasonic energy have become so perfected that applications are in prospect for virtually every sector of science and industry as well as the home, the doctor's office and the dentist's chair. Current applications are so many and so well accepted that they are worthy of study by research and development engineers interested in the improvement and development of products and processes.

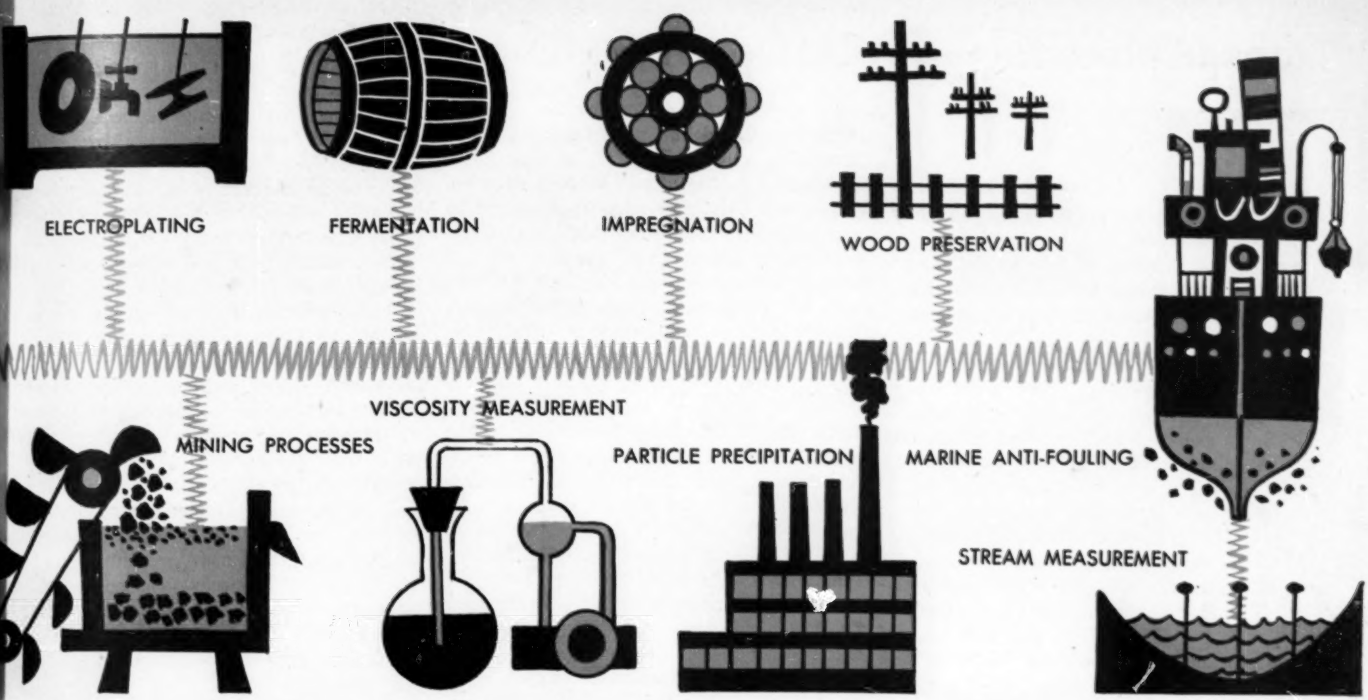
For the most part, ultrasonic devices are used in conjunction with liquids or solids in liquid phase. Such devices may be separated into two broad classes of equipment characterized either by the presence of, or the absence of, "cavitation" induced by high intensity sound waves. Cavitation, or "cold boiling", may be set up in liquids when the applied sound pressure is of sufficient amplitude to cause continuous rupture of entrapped vapor bubbles. The forces developed in the immediate locale of such collapsing bubbles are in the order of several hundred atmospheres pressure even though only a fraction of this pressure is required to initiate the process.

Two Major Categories

When cavitation is purposely developed, for example, to clean metal, glass and plastic parts which are immersed in solvent or detergent solutions, the soils, greases, chips, burrs, grit and other contaminants are literally torn away from the work by the tremendous forces associated with the cold boiling. Similarly, ultrasonically agitated dyestuff is dispersed to micron size by the collision forces of cavitation and is simultaneously propelled at high velocity into the deepest recesses of the fiber or fabric. As one would imagine, the addition of cavitation to textile wet finishing, and chemical processes as well, will yield far quicker and more uniform results at lower temperatures than ordinarily employed. Cavitation is, therefore, the modus operandi associated with practically all under-liquid ultrasonic applications.

On the other hand, ultrasonic gaging and inspection systems and other instrumentation generally operate at lower sound pressures which are below the so-called "threshold of cavitation". The familiar sonar equipment and the related depth sounders, fish locators and liquid level gages transmit pulses of moderate power which return as echoes some intervals to be measured later. Should the power deliberately be raised past the threshold of cavitation, the long distance performance would be severely limited by the scattering effects of the cavitation bubbles on subsequent sound waves. Thus, even though the sound energy may be increased in a liquid past cavitation level, the effective coverage of such ultrasonic instruments may be severely curtained.

In all ultrasonic processing systems using cavitation, there are marked similarities between the components required. In every case there is the need for an appropriate driving source and at least one transducer to convert either



Robert L. Rod

President, Acoustica Associates, Inc.

electrical, mechanical or hydraulic energy into sound waves. Although the electro-acoustic transducer is presently finding the widest range of applications as a result of its ability to handle large amounts of power, purely hydraulic and mechanical transducers will undoubtedly find a widening range of applications in the future as their development progresses.

Basic Techniques

Cavitation sets up in liquids under the action of a sufficiently intense sound source. If the power level is such that pressure amplitudes exceeding the hydrostatic pressure are developed for part of a cycle of applied alternating energy, the net external pressure becomes negative during the remaining part of the cycle, and collapse of the entrapped vapor bubbles takes place. This "cold boiling" condition may be produced in room temperature water by employing sound pressures above ⅓ watt/cm^2. The degree of cavitation induced by exceeding the threshold power does not increase linearly with applied power because of the so-called scattering effect, and, therefore, there is a point of diminishing returns beyond which an increase in power is no longer economical. Cavitation is most intense at the source of sound energy where it acts as a shield to successive sound vibrations. Fortunately, it is possible to generate copious cavitation some 6 to 12 inches away from the radiating face of a transducer despite losses set up by scattering, so that coverage need not be unduly restricted. Groups of strategically placed transducers are thus required to irradiate a large area with cavitation streamers.

The total power required, for example, to irradiate a surface measuring 100 cm^2 with cavitated water must be at least 30 watts and is generally selected to be from five to ten times this value for a margin of safety. Liquids of higher viscosity require more power to reach the cavitation threshold. Also, cavitation is more difficult to achieve if the liquid is under the influence of externally applied pressure. The proper selection of an ultrasonic processing system requires a complete knowledge of the liquid involved and its viscosity as well as the processing temperature and applied pressure. The power levels used and the number of transducers will then be determined once the operating frequency has been selected and the various factors determining threshold power considered. Frequency selection is important because the process may best be carried out at low or high frequencies and because more power is needed for cavitation above 10 kilocycles. Over ten times the power needed at 10 kilocycles is required to cavitate water at 400 kilocycles. Despite the need for excessive power, higher frequencies are frequently used in degassing, coagulating and dialyzing work which require maximum fluid particle acceleration, and in some cases, sharp beam focusing and high energy absorption. On the other hand, since sound energy is vibratory in nature, fluid particle displacement is a maximum at lower frequencies; thus larger objects can be cleaned or treated without shadowing effects, thereby eliminating the need for rotating the work as is necessary when higher frequencies are used.

Electro-acoustic transducers fall into two general groups: magnetostrictive and piezoelectric. In both cases, electrical driving energy is transformed into sound energy. In the magnetostrictive type, sound energy is developed by passing an alternating current through a coil surrounding a material whose actual dimensions change under the influence of a magnetic field. Usually, the material is nickel or a nickel alloy displaying a large change in dimensions per unit

Continued on page 22

MODERN INDUSTRIAL ULTRASONIC TECHNIQUES

Cleaning and Degreasing

Ultrasonics is finding widespread use in rapid cleaning because of the inherent capability of cavitation to reduce almost instantaneously the surface tension of clinging soils not only on visible surfaces but in the deepest recesses, blind holes and voids. Also, cavitation emulsifies greases and oils to assist in soil removal, particularly in a non-toxic water detergent solution. The violent motion of the liquid imparts a surface scrubbing action that expedites cleaning. Typical ultrasonic systems in present cleaning use are rated in power from 50 watts for a single transducer set to 150 kilowatts for a multiple transducer array, with the range of product size from transistors and hypodermic needles to complete automobile engine blocks. When ultrasonics is added to existing vapor-degreasing and solvent washing machines, the resultant improvement in cleanliness and the reduction in time amortizes the additional equipment expense in a matter of months. Ultrasonic cleaning, of course, lends itself to complete automation. Conveyorized ultrasonic systems have found universal acceptance in the metalworking industries.

Non-Destructive Testing

Two techniques are presently in use for ultrasonic thickness testing. The pulsed-type equipment functions on principles similar to radar by measuring the elapsed time required for a burst of sound energy to pass through a material from one surface to the opposite face and back again as an echo. Since the velocity of propagation for the material usually is known or can be measured with a sample of the same material having known dimensions, the thickness of the gaged piece can readily be determined knowing the transit time. A second type of equipment employs a variable frequency oscillator that is tuned until a standing wave of sound energy is set up in the material. Because the frequency and wave length are related to the sound velocity, it is possible to determine thickness of the material once the frequency is such that resonance is established. Both types of instruments are extremely useful in gaging wall thickness of objects having an inaccessible far surface and for locating flaws within intricate assemblies. Typical applications include the determination of storage tank wall and hull plate thickness, pipe dimensions and location of casting flaws and blowholes. The effects of rust damage, erosion and corrosion may be observed to insure adequate remaining thickness of material for the pressures involved.

Fatigue testing of engineering materials may be performed more expeditiously through ultrasonic techniques which also offer a higher degree of accuracy in the determination of endurance limits under a variety of combined stresses. High local forces may be developed in samples by using point-source transducers placed in direct contact with the work. Particle accelerations exceeding several thousands Gs are readily achieved. The combination of these two effects brings rapid destruction of materials in a small readily observable area of test sample. One of the advantages of ultrasonic fatigue and strength determination techniques is that bulky compression and tension-type hydraulic testing machines are no longer required, because highly accurate results may be obtained ultrasonically and on smaller samples.

Drilling and Grinding

Ultrasonic drills employ a tool-shaped transducer, or vibrator, that sets up cavitation in a surrounding liquid-borne abrasive slurry. The forces introduced by cavitation bubbles propel abrasive slurry against the work with such intensity that glass, metals and ceramics are easily penetrated in seconds in the form of regular and impossible holes. Die-shaped tools are used to carve intricate designs in tungsten carbide; while cutting knives are employed to uniformly slice the thin delicate crystal dies required in semi-conductor work. At present, the technique is restricted to small holes, but new advances in this field centering about improved transducers and tools are rapidly enlarging the scope of applications.

High frequency vibrations applied to conventional grinding operations in the control of work feed can improve surface finishes, reduce their temperatures and ground surface and reduce the incidence of thermal cracks. Vibrations of 0.001 inch amplitude at 10 to 18 kilocycles per second can result in a 60% reduction of roughness for from 40 to 16 micro-inches. When grinding hardened steel, while the temperature is reduced as much as 50%, the vibrations will enhance the grinding of single point carbide tools, producing a high finish on low carbon and alloy steels and aid in cutting dead soft aluminum.

Fluxless Soldering (Dip or Tool) of Metals, Particularly Aluminum

One of the most useful applications of ultrasonics is in the field of soldering aluminum. When cavitation is induced in molten solder, the resultant forces break down metal oxides formed on surfaces of the parts being soldered to expose the pure base metal to the solder in a non-oxidizing atmosphere. Perfect bonds can be made using ultrasonically activated solder pots or soldering irons having vibrating tips. No flux of any kind is required when soldering aluminum parts with an almost pure tin alloy solder. Brass and copper parts may be similarly joined with acid-free solder to give more reliable joints, especially suited to the continued passage of electric current. This is of particular interest in the electrical and electronic industries where problems in conventional soldering of connectors, printed circuits, tube bases, transistor cases and similar parts have presented numerous production bottlenecks. The corrosion usually developed over a period of time in metal parts soldered with the aid of acid and rosin fluxes is entirely eliminated.

Electroplating, Galvanizing

Another field of application for ultrasonics is in the electro-chemical field. Plating tanks fitted with banks of cavitation-producing transducers will produce more rapid and uniform work. The sonically induced cavitation streaming, coupled with a degassing action, will counteract the depletion of ions in the diffusing layer between electrode and electrolyte which usually limits the current yield under present plating techniques. Considerable economies in plating chemicals will also be effected when employing ultrasonics.

Impregnation

Ultrasonically induced impregnation is useful in oiling bearings and other parts having inaccessible surfaces as well as treating porous materials with preservatives. The application of fungicides to complex structures is also facilitated.

Emulsification of Resins, Oils and Water Solutions

Whenever some degree of success can be had in emulsifying immiscible liquids with soaps, detergents or catalysts, experience has shown that a more stable emulsion will be formed in a shorter period of time when ultrasonic cavitation is induced. Various ultrasonic systems are in use for this application and consist of both the conventional electrically driven transducer equipments and specially designed sound generators utiliz-

ing air- or liquid-driven mechanical resonators. The agitating action of cavitation makes emulsification feasible in a wide range of applications.

Pigment Dispersion, Particle Size Reduction

The reduction of particle size in such applications as printing ink, dye and paint manufacturing has long presented the most difficult processing problems. Particles within a sound field of cavitation level strike each other with tremendous force, causing almost instant disintegration and reduction in size which is molecular in many cases. Materials which have resisted efforts to reduce particle size to the micron range under the influence of ball mills and grinding rolls frequently break down as desired ultrasonically.

Continuous Viscosity Measurement

Several ultrasonic viscosimeters have been introduced in recent years. One of the most successful uses a thin knife-like blade immersed in the liquid being gaged. The blade is periodically vibrated by a transducer that is disconnected after the blade reaches steady state conditions. The rate at which the wand vibrations are damped by the liquid after the driving force is removed is a measure of viscosity. This type of instrument, which indicates viscosity directly, is suitable for low-cost remote gaging and recording and does not appreciably affect the flow of material being gaged. Similar equipment measures loading effects on piezoelectric crystals and translates the information into viscosity readings. Applications can be found for these versatile instruments in all process industries.

Accelerating Fermentation of Alcohols

The accelerating action of ultrasonic cavitation in hops extraction reduces both the time and temperature required to process beer. Taste is considered to be superior to beverage produced by conventional techniques. Accelerated aging of alcoholic beverages under ultrasonic irradiation has also been reported.

Degassing

A considerable degree of rapid degassing takes place in liquids through which comparatively high frequency sound vibrations are passed. The fields of applications in which this phenomenon is useful range from the canning of soups, juices and other vacuum packed products, to the manufacture of chemicals.

Homogenization and Sterilization

On a laboratory scale, the beneficial results of ultrasonics in homogenization and sterilization of bacteria-laden liquids has long been understood. The recent introduction of economical large-scale ultrasonic systems undoubtedly will lead to considerable practical use of the techniques, especially in the dairy, food and starch industries.

Natural and Synthetic Fiber Processing

The scouring of wool prior to manufacturing finished articles has long been a difficult and expensive operation. The removal of oil required to initially process the fibers can be expedited by exposure of the liquid detergent to cavitation-level sound energy. The resulting emulsification of the oil and detergent deep within the pores of the fibers will enable squeeze rollers to loosen the entrapped oils and soils in a fraction of the time formerly needed, and at lower temperatures.

Bleaching

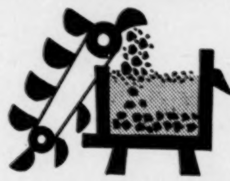
Conventional bleaching processes will be expedited with savings in bleach under ultrasonic irradiation. Uniformity will be enhanced in deep pile fabrics as a result of the improvement in penetration induced by cavitation.

Medical Instrumentation

Some of the most startling developments in ultrasonics have emerged from medical laboratories. Of highest importance is recent work in tumor detection using pulsed ultrasonic waves in combination with elaborate oscillographic displays. It is now possible to painlessly couple sound pulses through skin into the body and to differentiate between healthy tissues and malignant or non-malignant growths by analysis of the returning echoes. Sound energy of higher amplitude is used in the treatment of arthritis and to develop deep seated heating needed in the treatment of muscular disorders. Recent promise has developed in ultrasonic surgery wherein energy of destructive level is pinpointed at organs requiring resection. Successful lobotomies have been reported using this technique. In more conventional applications of ultrasound, medical workers are making active use of ultrasonic generators for cleaning and sterilizing hollow needles, slides, instruments and glassware and for emulsifying immiscible fluids. Sterilization action comes about by the destructon of bacteria subjected to intense sound vibration.

Metallurgy

A highly important application of ultrasonics is developing in the metallurgical industry for use in degassing such metals as aluminum and magnesium. When melts are exposed to ultrasonic energy capable of inducing cavitation, entrapped vapor bubbles of hydrogen and other gasses are driven out of solution thereby rendering subsequent castings free of blowholes and similar flaws. The violent motion also causes beneficial reduction in particle size which contributes greatly to increased strength and more uniform dispersion of alloy constituents.



Ore Processing

Ore benefication is one of the more recent applications of ultrasonics. Pulverized ore immersed in ultrasonically agitated water is frequently dispersed into its basic constituents more readily than by conventional separating means.

Stream Measurement

Ultrasonic gaging equipment is in use for determining stream levels and flows. Adaptations of the familiar depth sounder are in use, while instruments making use of the Doppler shift are employed to determine stream velocity. Applications for those newer techniques include reservoir monitoring and general hydraulic flow measurements.

Air Pollution and Particle Precipitation

One of the most promising fields of ultrasonic applications is that of de-smog and particle precipitation work. Aerosols exposed to intense ultrasonic energy tend to display particle agglomerization over a range of diameters not affected by conventional electric precipitators. In the past, moderate success was achieved in particle precipitation using ultrasonic sirens. New static-type ultrasonic "whistles" using compressed air as the driving source offer promise of even better results because of improvements in overall efficiency. In the near future, such generators should find widespread use in house incinerators, industrial flues and truck exhausts.

change in applied current. The magnetostrictive material is usually in the form of sheets of thin punched laminations bound together in a stack. When the current through the coil increases, the length of the stack will also change, and thus the stack will be set into mechanical vibrations. If the length of the stack is deliberately selected to be mechanically resonant at the applied driving frequency, as is usually the case, the motion is even greater. In practice, the end of the transducer having maximum motion relative to the other end of the stack or the center, depending upon the design, is placed in contact with the liquid directly or through an acoustically transparent "window". The window adds a measure of protection against corrosive liquids to the transducer but also introduces a transmission power loss. As soon as the acoustic output of the transducer exceeds the threshold, cavitation will be developed at the transducer-liquid interface. Since well designed magnetostriction transducers operated in the 20-30 kilocycle range have efficiencies of 70%, most of the applied electrical drive is realized as sound energy. The balance is lost as heat.

Magnetostriction transducers are used to energize ultrasonic drills, soldering irons, solder pots and crucibles. They find greatest application in large-scale systems because of their efficiencies and ability to withstand temperatures well over several hundred degrees centigrade directly and even higher temperatures with cooling provisions. The Curie point, above which magnetostriction no longer occurs, is 358°C. for nickel. When magnetostriction transducers are directly immersed in the process tank, cooling can usually be obtained from the liquid itself. Heating of single magnetostriction transducers not in direct contact with liquids is generally controlled by either cooling water or air blast.

Piezoelectric transducers are those in which the vibratory motion is obtained by impressing an electric charge across slabs of such crystalline materials as quartz, barium titanate, rochelle salt, ammonium dihydrogen phosphate and more recently certain ferro-ceramics. Those which deliver the most acoustic output per unit input voltage are generally the least stable electrically and mechanically. Quartz, the most stable of all piezoelectric materials, has a Curie of 576°C., but to obtain high ultrasonic output it is necessary to apply excessively high (and costly) voltage across the thin wafer generally used. For example, 40 kilovolts is required to obtain an intensity of 4 watts/cm^2 at 50 kilocycles. Insulation difficulties, arc-overs, unduly complex safety precautions and the like are rendering equipment using quartz for cavitation production obsolete. In instrumentation and therapeutic work, however, the inherent stability of quartz is highly advantageous.

Barium titanate is one of a family of artificially produced piezoelectric materials finding numerous applications in ultrasonics. Although the materials are severely temperature limited to operation below 100°C., they are characterized by high activity with rather low applied voltages. Titanates may be cast during fabrication to various shapes suited to focusing ultrasonic energy within a small area where intense cavitation can be developed for localized processing. Typical shapes include parabolic bowls and cylinders. Since the titanates are relatively inexpensive, considerable work is being done by ultrasonic engineers and ceramicists to improve their stability. Future advances in this field should greatly widen their areas of usefulness and displace some of the more costly artificial piezoelectric materials in sonar work and other precise applications.

For frequencies above 100 kilocycles the piezoelectric crystal transducers are more suitable because of lower internal losses. They become thinner, however, as the frequency increases and are somewhat more fragile. Magnetostriction transducers are used in most cases at frequencies below 100 kilocycles, especially when large-scale systems are contemplated. The advent of high-powered, motor driven alternators at 20,000 cycles has already created a certain degree of frequency standardization within the ultrasonics industry. At this frequency transducers are most efficient, while audible noise is not objectionable to humans.

Application Engineering

Optimum large-scale installation will operate (if feasible) at a frequency of 20,000 cycles using banks of transducers driven in tandem by the new motor-generator sets. Such an installation can be made for approximately $1 per watt of installed capacity at powers above 10 kilowatts. The cost per watt increases somewhat for the smaller single-transducer equipment finding widespread use for cleaning small parts, drilling and soldering.

Should a frequency higher than 20,000 cycles be indicated for a particular process, the cost of a large-scale installation will easily treble. The source of power must then be electronic which places the equipment needed in the class of a radio broadcasting station. It was precisely this condition which made ultrasonic processing uneconomic in the past when low-cost alternators were not as yet available.

A properly designed ultrasonic processing system will be a distinct aid in reducing costs, improving quality and maintaining competitive positions. Ultrasonic instrumentation can assist in many fields where existing equipment is either unavailable or less efficient for the task at hand. The barrier has been crossed; ultrasonics has come of age. ✖

Here's an intimate look at the contract—and costs—set up between a manufacturer and an outside development and design group in a

Controlled Crash Program For A New Product

C. Hotchkiss, Jr.

Stow Manufacturing Co.

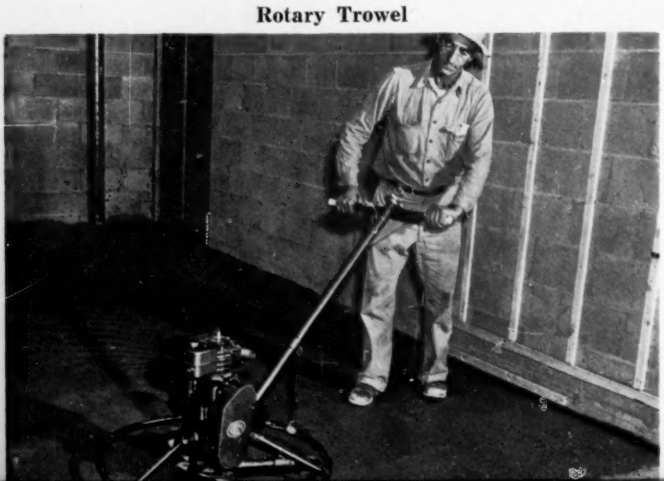
Expecting a loss of government contracts, the Stow Manufacturing Company of Binghamton, New York, decided they needed a new product to increase their commercial business. Their principal product is flexible shafting, but they also make a line of flexible shaft concrete vibrators which are sold through construction equipment distributors. Stow knew that the easiest way to get quick sales was through their present line of distributors, who were presented with a list of about 20 products already on the market that Stow believed they could make and asked to list the four they believed would sell best.

The results indicated strongly that a rotary trowel for finishing concrete, which was made by only a few companies, would be the best item.

The engineering procedure for the design of this trowel was laid out step by step as follows: (1) Survey including patent studies (2) Preliminary design (3) Preparation of layout drawings (4) Making up shop drawings (5) Building prototype (6) Testing prototype (7) Making design changes in prototype (8) Making up production drawings (9) Building one machine from production drawings (10) Testing this production machine and making necessary design changes (11) Ordering fixtures, jigs and tooling for first production run.

Now that the product was decided upon and the design procedure laid out, the big problem was *who would design the trowel?* For a large concern with many engineers this would be no problem, but for a small concern (116 employees) it was a huge problem because of the complexity of the product, the need to avoid certain patented features and Stow's desire to add features which would improve upon their competitors' machine yet sell competitively. Also, distributors wanted this machine in a hurry. If Stow designed the trowel themselves, they would have to take on extra engineers since their present small engineering staff was kept constantly busy with their regular work. On the other hand, if they engaged an outside design firm, the job could be done faster, but it would mean a large outlay of cash and less close job supervision.

Rotary Trowel



Stow decided to contact several outside design firms to see what they would charge for the design of this machine. Designers for Industry in Cleveland suggested that Stow make a "technical survey" before going into the design of the machine. The survey group is a separate section of Designers for Industry, and Stow would not be required to give them the design job upon completion of the survey.

Stow decided to proceed with the technical survey, and it was started immediately. Besides their own patent study, the technical survey team was to determine: (1) An estimate of sales (2) The overall picture of competition including the advantages and disadvantages of competitors' machines (3) What new features were wanted (4) An acceptable price.

Contract Details

The survey was made by interviewing competitors' distributors and contractors who used rotary trowels. They asked detailed questions about the product and what improvements were thought necessary. As an independent design firm, DFC had no trouble getting this information from distributors—information useful not only in confirming Stow's estimate of the potential market, but also in the actual design of the product. The survey took 248.3 man hours and cost $2,086.90 plus $365.43 traveling expenses—a total of $2,452.33.

A preliminary report on the survey was submitted, and a conference was held just two months later to discuss the results. Stow asked Designers for Industry to present a proposal for just one size machine which would include designing and building the prototype, testing it and making the production drawings. The proposed estimated costs are shown in the table on the opposite page.

Stow gave the design job to DFI with the stipulation that they submit a preliminary design which would not infringe any patents, for their review before proceeding. This plan was covered by items 1 and 2 in the proposal and had an estimated budget of $1,840. Therefore, DFI was not to proceed further with the design than this amount without Stow's approval. This procedure gave Stow a degree of control since no more than $1,840 would be spent before they checked the design.

Stow prepared the following list of features to be considered by DFI in the design:

1. Size—Since only one model is in question at this time,

ESTIMATED COSTS

	PROJECT MANAGER	PROJECT ENGINEER	PROJECT DESIGNER	DESIGNER	DRAFTSMAN	CHECKER	MACHINIST
Patent Studies & Evaluation	15	30					
Conference: Modifications	5	50	40		80		
Preliminary Design	5	30	30		40		150
Practical Experimentation	10	10					
Final Design		40	40	40			
Client Report: Modifications	5	20					
Design Execution		20	20	20	200	50	
Prototype, Build, Test		40		20	40		300
Production Engineering		50					
Total Services in Estimated Hours	40	290	130	80	360	50	450
Service Rate Per Hour in Dollars	15	10	8.5	7	5	8.5	6
Total Estimated Service Cost	600	2900	1105	560	1800	425	2700
Total Estimated Labor		$10,090.00					
Materials & Miscellaneous		500.00					
TOTAL ESTIMATED BUDGET		$10,590.00					

size should be determined on basis of most popular competitive models.

2. H. P.—Gasoline engine must be of sufficient rating to drive machine for floating as well as finishing with recommended, preferred makes.

3. Speed—Variable speed control at handle to cover range required for floating and finishing.

4. Power Transmission—Long-life with oil seals to give trouble-free service.

5. Trowel tilting mechanism—Must be reliable and adjustable at handle while machine is in operation.

6. Trowels — Interchangeable floating or finishing. Sturdy long-life and easy to change by one man. Must be guarded against striking obstruction and damage.

7. Centrifugal Clutch—Consider automatic throttle release to avoid rotation of handle when accidently released.

8. Handle must be sturdy for proper control of machine propulsion, adjustable to suit operator's height. Also, consider possibility of folding for space conservation in transport and storage.

9. General Construction—All vital parts should be adequately guarded or protected against damage from rough handling in transport from job to job.

10. Engine mounting—Consider possibility of conversion to electrically driven machine when designing power transmission engine mounting surface.

Notice that these were constructive rather than restrictive comments. They were based on the technical survey and comments by distributors. Since Stow had very little experience in the troweling field, they left the design wide open to DFI indicating only that they wanted a machine that was superior to those then on the market and that could be manufactured to sell at a competitive price. By not being restrictive, Stow hoped to get many novel ideas in the design. DFI estimated that they could complete the prototype in 90 days.

Six weeks later a conference to discuss the preliminary design was attended by the President and Vice-President in Charge of Engineering at Stow and the President, Product Manager and Product Engineer of DFI. Stow examined the preliminary design and suggested a few changes which were discussed thoroughly. Those decided upon were written up in detail. Stow stated what the manufacturing cost should be, based on their factory rate for labor and material costs.

DFI was given authority to prepare assembly and layout drawings based on the preliminary design and the changes discussed. Assuming that all the requirements in function and production cost could be satisfied on paper in time, a second meeting was scheduled in Cleveland ten days later. Following this meeting DFI was given an O.K. to start with the shop drawings from which the prototype could be built.

Contract Termination

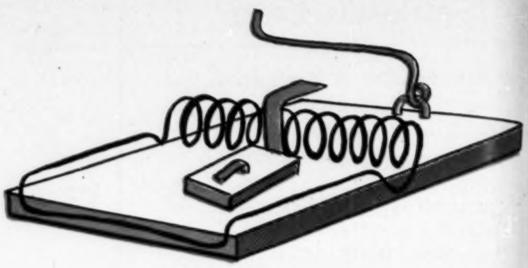
Details on the prototype design were given to the Stow sales department for discussion with their distributors. As a result several design changes were made including the make of the engine. Distributors said that the machine would not sell with the proposed make of engine as it was not well known in the field.

The prototype was completed and shipped to Stow four months after the start of the design. Testing on a slab was begun immediately and compared with competitors' models on the same job. As a result, some changes were made in the machine, particularly in the method of supporting the blades. The machine was tested further. Pictures of the prototype were sent to all distributors, some of whom suggested design changes. One accepted suggestion was to lower the height of the guard ring so that the machine could go under pipes which are often only six inches above the concrete.

At this point Stow decided to do the production drawings themselves rather than let DFI do them as originally planned. Stow believed they could make these drawings more quickly since they naturally knew just which machines required parts. All work was terminated immediately with DFI. The breakdown on the cost of design to date excluding the technical survey was as follows:

	RATE	HOURS	COST
Project Engineer	$10.00	296.2	$2,962.00
Project Designer	8.50	17.7	$150.45
Project Manager	$15.00	10.0	$150.00
Layout Designer	$7.00	318.7	$2,230.90
Machinists	$6.00	445.6	$2,673.60
Laboratory Assistant	$5.00	2.1	$10.50
TOTAL COST			$8,177.45

Developing "creativity" in engineers has not as yet succumbed to any "how to" formula. But here are some examples of what can be labeled



Creative Engineering—Applied

Alexander C. Wall

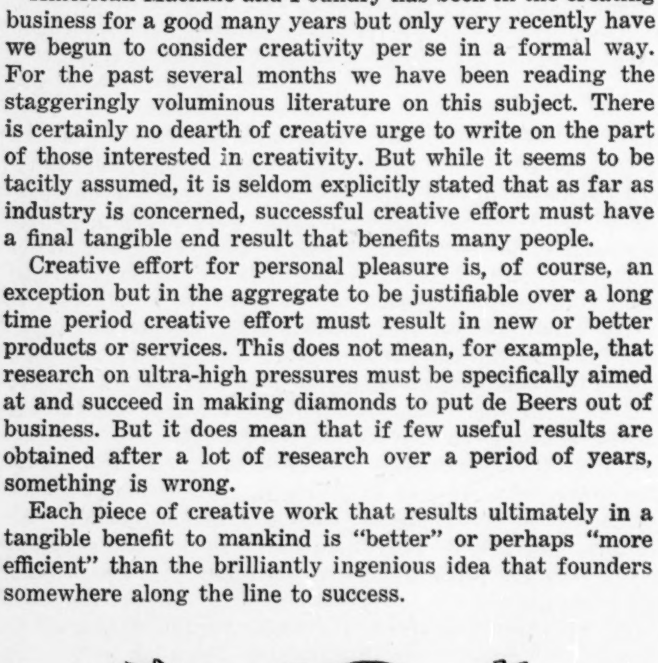
Director of Research and Development

American Machine and Foundry Company

American Machine and Foundry has been in the creating business for a good many years but only very recently have we begun to consider creativity per se in a formal way. For the past several months we have been reading the staggeringly voluminous literature on this subject. There is certainly no dearth of creative urge to write on the part of those interested in creativity. But while it seems to be tacitly assumed, it is seldom explicitly stated that as far as industry is concerned, successful creative effort must have a final tangible end result that benefits many people.

Creative effort for personal pleasure is, of course, an exception but in the aggregate to be justifiable over a long time period creative effort must result in new or better products or services. This does not mean, for example, that research on ultra-high pressures must be specifically aimed at and succeed in making diamonds to put de Beers out of business. But it does mean that if few useful results are obtained after a lot of research over a period of years, something is wrong.

Each piece of creative work that results ultimately in a tangible benefit to mankind is "better" or perhaps "more efficient" than the brilliantly ingenious idea that founders somewhere along the line to success.



Creativeness in engineering has many facets, and for this reason it is an exceptionally difficult type of activity or process to define. Many types of creativity exist and it takes all kinds of people that operate in the different areas to apply a creative process efficiently. A description of some of AMF's activities in creative engineering will best illustrate the elements of creativity as we interpret them.

These experiences indicated to us that creativity in engineering comes in several categories each with several models. An essential first facet is a new, bright, practical idea for a problem solution. But as the mathematicians say, "This is necessary but not sufficient". By way of Mr. Aesop (who was not a mathematician) we would like to relate some true fables.

Fable of the Mechanical Girl

Shortly after World War II AMF managed to create a successful pretzel tying machine—fingerprints and all. So sure were we that it was the "impossible invention" that we paid scant attention to possible competition and proceeded to test the machine and plan for production.

Our work took place in the days of difficult procurement and slow deliveries. Frankly, we were disturbed when we learned that a competitor had a different machine that did not infringe on our patents and that its production was almost fact.

An industrious battery of mechanical girls can cruise along for days at about 1000 pretzels per minute (maybe 1,500,000 pretzels a day when beer sales boom). At this rate the mechanical girl population did not need to be large to supply the national demand. In short, there was room in the field for very few machine manufacturers. We realized that the company getting a substantial number of machines out first would probably dominate the market.

Under the circumstances six months was a long time, and deliveries of pieceparts were running to 18 months. The engineers were stretching their imaginations and creative abilities to devise substitutions and "design

arounds". One particular spring in the machine was critical and was holding up everything. We were about to "design around" it when our purchasing agent walked in and handed us a spring saying: "How's this?"

"Where did you get it, and how many and how much?" several of us chorused.

The purchasing agent replied: "During the war mousetrap production was permitted, so I just bought a bunch of mousetraps that happen to be in good supply now and cheaper than the quotations on the springs"

Professor John E. Arnold of MIT has given us a very useful concept of analytical and creative problems. The analytical problem has one "right" answer while the creative problem may have several satisfactory answers. The dilemna of how to get springs in an impossibly tight market when solved by buying mousetraps certainly fits the definition of a creative problem. To my mind our purchasing agent was a creative fellow. True, his reasoning process was not as elegant as that of the engineer who invented the pretzel tyer nor did it require the formal knowledge, but it saved the day.

We stripped local hardware stores of mousetraps and performed several hundred other similar creative acts. Finally the machines were shipped to several field locations and production began, the lead safely in AMF hands, we thought. Practically all our development work was done in the fall and winter when the weather was nice and dry. It was summer when the first machines went into operation, and the humidity was high. Our mechanical girls would not tie pretzels without getting their hands completely stuck with dough. Production bogged down. Our competition began to breathe heavily down our necks. We heard that they had a completely successful operation in full swing at Scranton while our machines looked like nothing more than a four-year-old caught in Grandma's cookie dough.

Quite naturally we turned on our creative processes: air condition the bakeries (air conditioner delivery three years—expensive too); coat the machine with the new wonder plastic Teflon ($24 a pound and available in half-pound lots); apply dusting powder (when it worked, the resulting pretzels had bad cases of white measles).

At that time, fortunately, we had a very creative sort of serviceman—no formal training but smart and not afraid to think. He knew he could dry his hands by waving them in the air when a towel wasn't handy, even on a damp day. He rigged up a little furnace blower to pass air over the stick during its 50 millisecond rest waiting for the pickup fingers. A trained creative engineer might reject the idea of drying action of 90% relative-humidity air on anything in 50 milleseconds, but it worked.

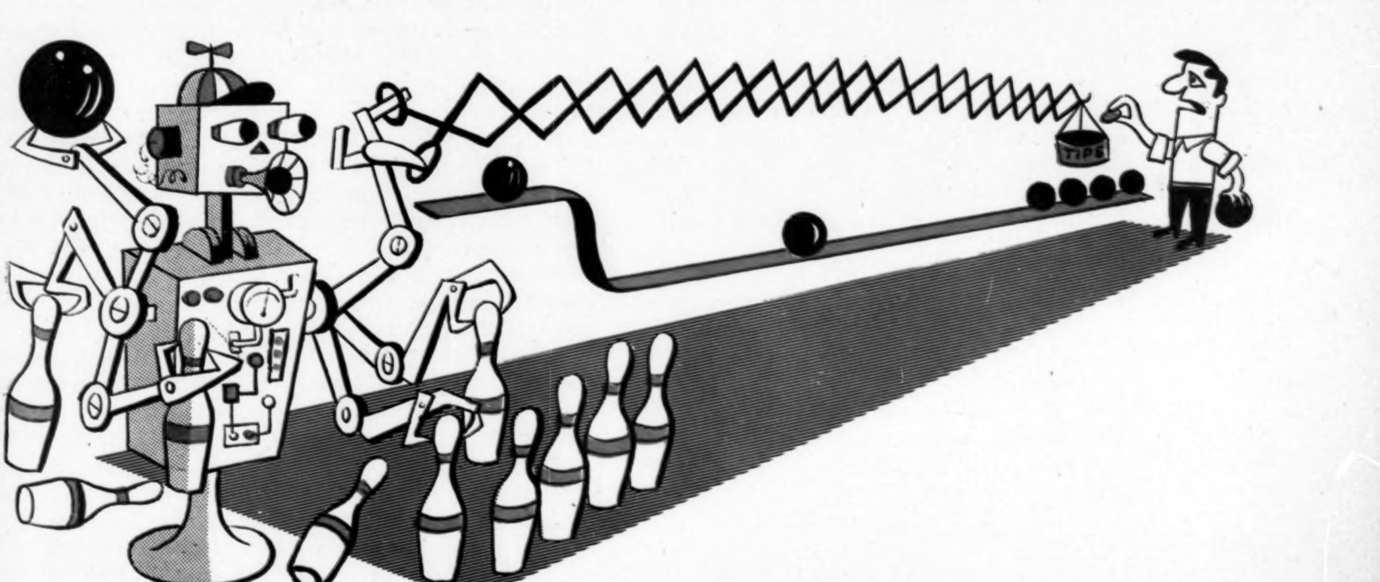
This ends our first fable. We think it has two morals: first, creativity resulting in something of use to mankind is a process covering a space of time, not a single inventive or creative act; second, there seem to be several kinds and shades of creativity and an organization's ability to create successful new products depends to a considerable extent upon that organization's ability to effectively bring all these kinds and shades of creativity into play.

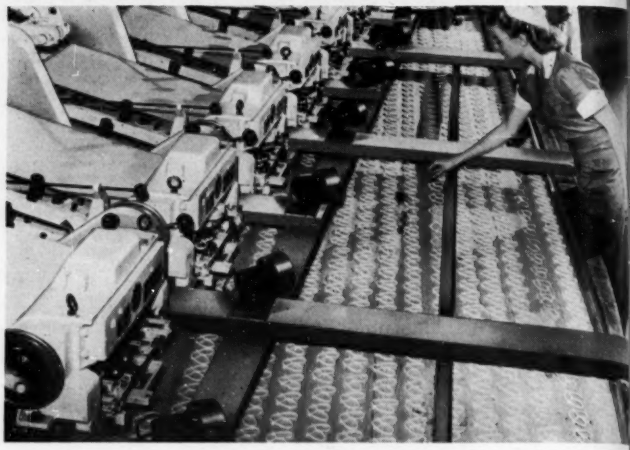
Fable of the Mechanical Boy

And now the fable of the creativity problem that required the opposite of invention for its solution—the mechanical pinboy. The size of the market (60,000 machines having a gross potential of $1000 per machine per year) had stimulated inventors all over the country. Patents were many and activities continuous. Despite efforts dating back to 1912, however, there was no successful machine or even one that approached success.

By 1947 after some eight years of effort (with time out for World War II), AMF had a working pinspotting machine. It did not, however, satisfactorily combine the conflicting requirements of operating function, high reliability and low cost. This clearly appeared to be a problem requiring creativeness and invention. No one seemed able to get the right combination of mechanical arms, legs, eyes and brain to make an efficient pinboy.

One day one of our engineers, with a different turn of creative mind, looked at all the individual mechanisms which we had available to perform each job the pinboy performs. A little simple mathematics showed that there were enough proven units from which it would be possible to construct about 10,000 different machines, each of which might spot pins successfully. We were attempting to solve this problem by using teams of creative engineers—we'll call them Category I engineers—to create, construct and test experimental machines. What this amounted to was





Expert pretzel twisters can make 32 pretzels per minute for short periods of time against 55 per minute from the AMF machine. Each machine accounts for a row of pretzels in the above diagonal installation.

that we were trying 10,000 possible combinations, one at a time. The probability that we would hit the right combination in an ordinary lifetime seemed distressingly low.

In short, we were swamped with ideas, and we hardly needed more creative ideas from engineers of Category I. What we did need was focused and restricted thinking, but it still had to be imaginative and contain the elements of creativity. We needed a new kind of creative engineer; let's call him Category II.

Machines that worked well cost too much, and the ones that cost about right were unreliable. We knew what our costs had to be to make our machine economically sound. Our Category II creative engineers were able to analyze several machines and find that a relation existed between the distance a pin traveled and the manufacturing cost of the machine. This distance turned out to be quite low and drastically reduced the possible combinations we need consider. In effect creative engineers of Category II said to creative engineers of Category I: "If any idea you come up with, no matter how clever, causes the pins to travel more than x feet, forget it. It's no good."

This concept gave our creative engineers of Category I a sense of direction on what to do to invent a machine that would have the right manufacturing cost, but it was no help at all in how to make the machine reliable. While you can influence a human pinboy's reliability by sliding quarters down the alley, the mechanical pinboy has to be reliable all by himself. Visualize a machine that is relatively complex, quite large and handles both bowling pins and balls. Pins change in dimension as they age due to chipping and being turned down and refinished. The machine has to handle 16 pound balls, new pins, old pins and hard maplewood chips without complaint. To keep maintenance costs within bounds it is necessary that in performing 100,000 pin handling operations, the machine develop no more than six malfunctions. This is an efficiency of 99.994% and represents aircraft grade reliability where we cannot afford aircraft construction methods.

We were able to get a sense of direction on the manufacturing cost problem by having creative engineers of Category II find a relation in existing machines between the way the machine worked and its cost. This would not work here since we did not have any machines with sufficient reliability. It seemed as though we needed a creative engineer of still a different type; let's call him Category III. He had to figure out how to make a machine we didn't have fundamentally reliable. Since no reliable machines were available to examine, this had to be done in the abstract.

The first step was to divide malfunctions into two classes: mechanical failure; and motion of a ball, pin or wood chip into an unwanted area. Disposing of the first class of malfunctions was relatively easy. We set up a group of super critical, deliberate engineers who exhaustively analyzed and tested every mechanism we intended to use. Their word was law, and no creative idea of any category was approved for use without their O.K.

The second class of malfunctions was more troublesome. It was a case of the perversity of inanimate objects, and that we were aware of this was proved by little signs we had around the Lab which read: "Bowling pins are apt to assume improbable positions, usually to our disadvantage."

Our engineers of Category III developed an abstract mechanismless theory (or language) of pinspotting, based on a visualization of what the pins and balls had to do to accomplish their missions, irrespective of the mechanisms. We developed terms to describe their actions: separation, alignment, orientation, elevation, triangulation, spot and respot, to mention a few. The Category III engineers were then able to describe what surprisingly turned out to be a limited number of classes of permissible methods for doing the job. It was then possible to analyze these classes in terms of parameters that contain randomness possibilities. In other words, we could see that certain methods tended to decrease the opportunity for perversity of our inanimate pins, balls and wood chips. The result of this activity was the establishment of a set of rules which when followed by the creative engineers of Category I would tend to keep malfunctions due to randomness to a low value. That these two schemes worked is proved by the fact that the 5000 machines in the field at present, with 300 going in every month, now run with an efficiency factor of 99.9995% or five troubles per million operations.

This ends the fable of the mechanical pinboy. We feel that the mechanical pretzel girl fable illustrates that it takes many kinds of creativity, extending possibly over a period of years from the initial invention, to make a creativity program successful. We feel that the fable of the mechanical pinboy illustrates that even the initial act of making the first invention may require creative effort of several categories. There seems to be a tendency in current literature on developing creativity to seek for or to define a single set of temperament attributes which if com-

bined in an individual and properly fostered would produce a creative engineer. It would seem that if we set up courses and psychoanalysis methods to train and measure these traits, we would solve the problem of providing an ample supply of creative ability for all time. We believe, and we hope these stories illustrate, that there is no single set of attributes which will define a creative engineer.

Cures That Kill

Unfortunately, the problem does not appear to be that simple. The development of pure ingenuity can sometimes cause more problems than it cures. Some years ago we had an interesting and humorous case in point. We had just completed the development of an automatic attachment to the cigarette packing machine. This attachment was to insure that every pack contained 20 full cigarettes. 60 machines had been installed and were operating in one large factory. Suddenly, we received complaints that packs were going out with 19 cigarettes. This occurred quite infrequently, and with the millions of packs being made it seemed an almost hopeless task to locate the particular machine at fault. Someone got the bright idea of having each packer print its own number under one of the side folds in the pack which was firmly glued down. When a pack was returned with 19 cigarettes, we could carefully moisten and lift the glued side fold and identify the culprit machine.

The condensed diary of the flood of letters we received following our June 1 installation of this method would read somewhat as follows:

June 6 — "Dear Sirs:

We understand you are giving valuable prizes for the lucky number in the side fold of your cigarette pack."

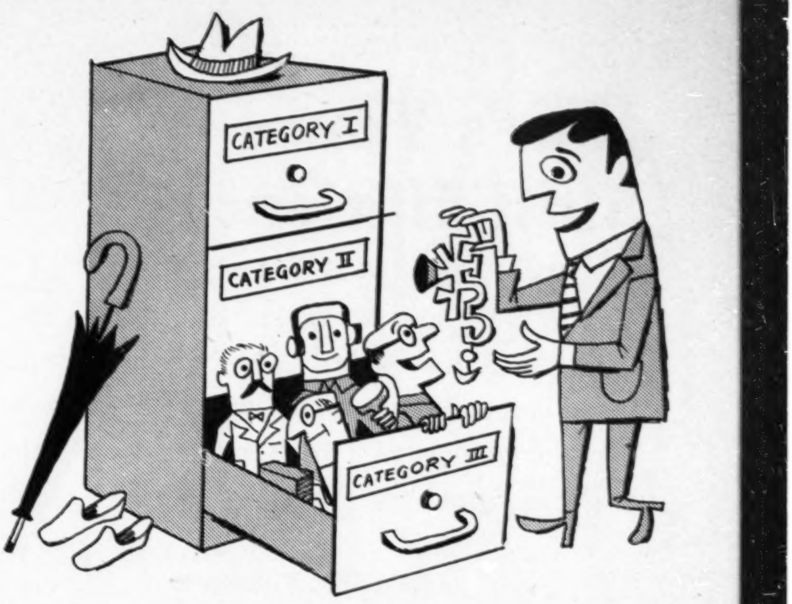
June 8 — "Dear Sirs:

Please tell me the lucky number on which I can get a new Ford."

June 10 — "Dear Sirs:

Herewith is package with #33, and where can I go to get my new Cadillac?"

As you can imagine, we promptly removed the numbers



from the machines and had a battery of stenographers type diplomatic replies. This experience illustrates that something which may be very simple and ingenious in one part of the creative process may have totally unexpected results somewhere along the line. We believe it emphasizes Professor Arnold's other concepts of the complete creative engineer who could think broadly and through all stages of the process, even outside of engineering.

Categories of Creativity

Now, if these ideas have some merit—namely, that initial creativeness may require several distinctly different categories of creative thinking, and also that still further different categories of creativity are required throughout a long process—what can be done about it? At the present moment, we don't pretend to know how finely these categories should be broken down nor exactly how to go about it. We have made some small starts in both directions. There seem to be common threads running throughout the creative engineering process. There seem to be some universals present. To what degree these universals will be things people possess intrinsically, relatively unchangeable, like blue eyes, and to what extent they will be changeable by training, like habits of speech, we cannot tell as yet. It seems to be a problem that requires the application of both engineering understanding and psychology.

We have retained an industrial psychologist to consult with us and carry out some preliminary exploration. We have not reached a point where we can report on specific progress, but several intriguing ideas have developed. It seems that the kinds of creative effort required can be grouped into a limited number of classes. It further seems possible to describe the human attributes in recognized psychological terms which will be required to deal with the problems in these classes. Also, it seems that the combination of attributes which tend to be found in single individuals can be correlated with the actions required. If the gist of these ideas is sound, it should make the problem of developing creative engineers somewhat simpler. We should have to turn out a somewhat smaller percentage of the difficult-to-develop true Category I inventors and many more creative engineers of the other categories to carry through and finish what the inventors start. ✖

How's Your Staff Efficiency?

Your staff is only as good as the energy, initiative and imagination the individual puts into his job. Your success as a R/E manager depends on how well you apply these 18 rules to get maximum performance from your men.

Luis J. A. Villalon
Management Affairs Editor

An executive has a lot in common with a jockey, a racing driver or a fighter pilot. They all have the same job—to get maximum performance from the machine, animate or inanimate, that has been entrusted to their care. This takes a lot of skill—and the executive who is handling the most intricate mechanism of all, has the most demanding task.

And there are reasons to believe that the research executive has an even more difficult challenge. He is dealing with a high level of talents and usually an extreme degree of individualism. In the research area, maximum performance can mean a near-miracle. Minimum performance, on the other hand, invalidates the whole purpose of the research program.

Experts on the executive function have been saying this same thing in different ways for a good many years. Chester Barnard, president of The Rockefeller Foundation, once said that the job of the executive is "to maintain a system of cooperative effort", while F. J. Roethlisberger, Professor of Human Relations at the Harvard Business School, has said that the boss's challenge is "to achieve a balanced relationship between the logical organization of operations and the social organization of teamwork". In short—to get the most out of your staff.

Industrial psychologist, Dr. G. L. Freeman, goes on to say, "In handling scientific personnel, the key problem is to stimulate them to bring into play the energy, enthusiasm and idealism that brought them into a research career in the first place. Psychologically speaking, this means putting to work the same tools that would be applied in any leadership situation—only more so."

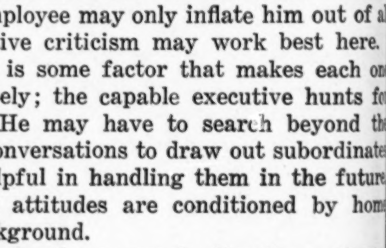
The eighteen practical rules that follow are designed to help the research director get things done—through the people he has in his employ. They are based on the experience of dozens of successful administrators, as interviewed by business journalists and industrial psychologists. R/E offers them with the confidence that they will help any management man build an alert and eager staff, and then get the most out of it on a month-to-month and year-to-year basis.

1 Find out what makes them tick.

People aren't just names or numbers on a file card. They're widely varying individuals, and the research staff tends to vary most widely of all. The individual's motives and attitudes are the main tools the executive has, and they can be determined only by study. In many, security is the main drive. In others, well-timed praise may be the answer to reach heights of effectiveness. But the same formula applied to another employee may only inflate him out of all usefulness. Constructive criticism may work best here.

In any case, there is some factor that makes each one operate more effectively; the capable executive hunts for it until he finds it. He may have to search beyond the office. A few casual conversations to draw out subordinates can be immensely helpful in handling them in the future. After all, everyone's attitudes are conditioned by home life and personal background.

Paradoxically enough, the research director, scientifically trained knows all these things very well—but is sometimes least inclined to supply his rules to people.



2 Be a good listener.

Keeping one's ears open isn't only useful in finding out what makes people tick. It's also a good way to convince them they belong, to build up their feeling of accomplishment and importance. A good executive encourages them to talk, to ask questions—by listening. The fellow who always dominates the conversation only encourages them to be silent.

Some ideas your subordinates come up with may sound fantastic, but it's important not to let them know it. Dis-

paragement or ridicule effectively stem the flow of ideas —and the next idea may be just the one you want. Many a researcher needs the opportunity to talk out a problem— if only to blow away his own cobwebs.

Sure, it takes time to draw people out, to hold their hands, to listen to their problems. But in the research area, where the difference between a dud and a significant development may be just one added thought, the boss's listening time is well spent.

3 Be careful of criticism.

Before you criticize, be sure you have all the facts—and then suggest a constructive course for the next time. Don't question the motive when it's the method you're worried about. Occasionally, it's a good device to praise a bit before you criticize, but if it's done too often, it will be recognized as insincere. The most important rule of all is to criticize in private. Reprimands in front of others only cause resentment and undermine the authority of the man being criticized.

4 Use praise — in public.

Lean over backwards to give credit. A wise executive never allows himself to be accused of grabbing credit for himself. He realizes that his credit comes in the building of an able staff. Subordinates will only take responsibility and use initiative if there are rewards in sight.

And when there is praise to be handed out, it has a double impact if it's tendered publicly. It's good for morale and self-confidence and sends your man back to his laboratory doubly-determined to keep his standing high. One warning: Make sure the fellow you praise is the one who really deserves it, and that those who helped him get recognition, too.

5 Delegate responsibility.

The boss who insists on attending to all the details discourages his staff by competing with them. No one is an executive who doesn't delegate. The capable employees will quit, and the others will just sit back and rest. In the meantime, the boss will have no time for the thinking and planning that are essential to his job.

6 Persuade — don't domineer.

The old saw about leading a horse to water couldn't apply to anything more aptly than it does to a research and development operation. The R/E director can make his people go through the motions, but he can't make them really think unless they want to. A domineering executive only breeds "yes" men. The real leader thinks of his staff working *with* him, not *for* him.

Suggestions or requests work a lot better than orders with people who have initiative and ability. If only orders work, you'd probably be better off looking for some new assistants. Warning: Your suggestions must be specific. People can't follow orders or suggestions that they can't understand.

7 Set the example.

It's a simple point, but never forget that the executive sets the style for his own people. If he's irregular in his habits, late for appointments, careless about facts, bored with it all, they will be too. But most people would prefer to follow a good example, if you'll only give them one.

8 Tell them why.

When you make a request or give an order, be sure to give the reasons. Intelligent personnel—the kind that work in a research department, do things well only when they know why they're doing them. It doesn't matter whether the expanation is oral or written—just make sure it's there. This "tell them why" principle applies in other directions. Suppose you do adopt an idea from one of your staff? Make sure he knows why, so he'll apply the same line of thought to other problems that got results in this case. Of course, this applies doubly when the idea is rejected; if your reasons are good, he'll buy them, and if not, maybe it should have been accepted.

9 Ask for help.

Nothing brings your subordinates into the picture more effectively than asking them for their advice and help when you're attacking a tough problem. And, remember, this doesn't only build your staff's self-confidence—it may turn up some good ideas that you would never have heard of unless you asked for them.

10 Act like a human being.

Even the coldest-blooded executive can easily take steps to warm his relations with the people on his staff. For instance: use first names; make occasional unplanned luncheon dates with one or two at a time; find a way to

mention hobbies, family news or other not-too-perso matters; arrange informal bull sessions on business or no business topics.

Interest is also shown by the boss who keeps a sha eye on his subordinates' work-load, and similar matte An occasional "Joe, you've been hitting the ball pretty ha lately. How about taking tomorrow off?" does wonders results. Moves of this sort will pay dividends many tim over in loyalty and accomplishment. And they don't far enough to violate another rule that many executiv believe is sound: keep your business and personal liv separate.

11 Don't blow your top.

The first rule in building a loyal team is courtesy. Tre pride, personality and self-respect as assets instead trampling on them. Remember, what the boss says has special meaning and importance. An unintended inflectio a careless choice of words, an ill-timed joke, can all bre misunderstanding and insecurity that interfere with ef cient work. When you're going to have an important ta with an assistant, try to plan it out in advance.

Above all, keep your temper. And don't be annoyed b internal grousing; it's a perfectly normal safety valve th occurs in practically any organization.

12 Be consistent.

Whereas the boss who blows his top frightens subor dinates into their shells, the moody fellow just bewilder them. A leader who jumps around like a bug on a h griddle can't win the confidence and support of the peopl under him. One can follow only when the leader's cours is steady, and reactions predictable.

13 Keep them informed.

The members of a team feel entitled to know wha going on. Try to let your assistants in on plans and pro jects, even at an early stage. It will give them that all-im portant sense of participation. When they've had a part o the shaping of a plan, it becomes as much theirs as yours Accordingly, they will feel personal responsibility for it success.

14 Build them up.

The able employee—the one who can develop into a company officer—usually doesn't start clicking until he feel that he has an important job and is essential to it. The he will tend to perform according to what is expected o him. If he knows his boss has confidence enough to expec a first-rate job, that's what he'll give him. It you want t build capable assistants, start with their self-respect.

15 Admit your mistakes.

You can't be wrong too often—but an executive doesn't lose face when he admits an occasional mistake. After all, you might be surprised to discover just how fallible your subordinates think you are. When you frankly admit you're wrong, your stock will climb through demonstrated fairness and honesty. Some have suggested that executives ought to make occasional mistakes deliberately, just so they can admit them—but this isn't likely to be necessary!

16 Give them something to work for.

Just as a research problem needs an objective, so does the researcher need a personal goal, a sense of direction, a something to strive for. In either case—career-wise or project-wise—he needs to know where he's going, what he's doing, and why he's doing it, in order to plan his course intelligently and work effectively.

The really capable junior just can't get interested in working from day to day. He wants to see his particular job in perspective with his department, company and industry. He wants to know how it relates to promotion possibilities and to his future income.

17 Let them get into the act.

Let your people help make the plans so they feel a responsibility for carrying them out. When two ideas of equal merit crop up, it's usually good strategy to choose the one developed by the person who will carry out the project. He will feel personal responsibility in proving that his idea is workable. It's good executive strategy, therefore, to plant the seeds of ideas in the minds of others, so those who execute them will feel they are their own.

18 Let them know where they stand.

With every company bidding for able research personnel, it's not enough just to hire a man, pay him his salary and forget him. He has to feel that he's making some progress—or, if not, has to know why. There are a lot of ways to accomplish this, ranging from a formal rating system to periodic talks between an employer and an employee, dealing frankly with abilities and faults alike. How you accomplish this point doesn't matter—as long as you do.

The sense of this article has been concerned with getting the most out of a given research staff. These eighteen points, if followed, will go far toward accomplishing that result, regardless of the state of the labor market. But, in an era of unprecedented shortages of scientific personnel, the same points will accomplish an even more primary objective—keeping an effective working team together after you've been able to find them. Never was the premium on research management as high as in this tenth atomic year.

✖

You need more than technical competence to

Sell Your R/D Services

Clinton F. Heil
Assistant Director, Engineering Projects
Ordnance Research Laboratory

On various occasions personnel of the Ordnance Research Laboratory are requested by the Bureau of Ordnance to visit industrial facilities engaged in research, development and manufacture of equipment. Visits to these facilities are made to evaluate their ability to repackage, product design and production engineer previously developed equipment for production with standard tools and facilities available to American industry.

Frankly, our personnel feels that a great amount of time has been expended needlessly and unprofitably by us and personnel of the facility contacted. During such visits we are usually greeted with questions concerning what we want to find out. We have come to regard this type of greeting as a standardized negative approach. After we express our desires and wishes, we are given a "pep" talk on the virtues of the company, a tour of the facility, a sumptuous luncheon, and finally a "how good we are" dissertation with "I hope we get the contract" as a parting shot.

Over the years we have been impressed with the time and effort spent by industry in evolving vast sales organizations to make the general public aware of their products. We feel that some managers of research, development and production facilities overlook an important opportunity: efficiently and honestly presenting a picture of their products, available facilities and services to buyers such as the U. S. Government. All hope to obtain a contract but not enough sell their organization in a positive way. It would be difficult to measure the effectiveness of the various techniques employed by industry to point out to people visiting their facility just what they can do; from a buyer's standpoint we would like a more positive approach. We do not suggest that industry prime its employees to give the correct answers at the correct time, but rather that management adopt a more positive approach.

Initial Contact Errors

Management makes its first mistake during the initial contact, usually a telephone call that we open with:

> "We would like to visit your plant and find out if you have the available facilities for some government work."

The customary reply is that they will be pleased to have us visit them and that we shall be met by one of their personnel and taken to their plant. We are seldom given an opportunity to expand on our mission since the contact usually terminates at this point.

We would prefer that, during our initial contact, management ask us specifically what type of work we have in mind, our reasons for visiting their facility and the nature of the job—whether it is one of research, development, product design or production. They could also make some effort to obtain background information about us of the type in the check list on the following page. The combined information—who we are, what we do and what we want done—would enable them to set up a realistic and informative agenda for use during our visit.

It is annoying to be asked what we want to find out during our visit. This information should be determined beforehand so that management could prepare proper answers. Then it would have been possible for them to say:

> "We understand you are visiting us for the following reasons . . . To give you this information we would like to present an outline of our entire organization with emphasis on. . . ."

Management could then trace for us in a functional way how jobs are handled with special emphasis on how they keep jobs flowing through their various divisions. The next step would be to have them conduct us on a tour of the plant with every opportunity to see their facilities, to talk with the working personnel, to review the work they have done and the work they are doing. Particular emphasis should be on facilities and hardware related to our interest.

After the functional, operational and physical facility potentialities have been presented, management could tell us how the job we have in mind could effectively be handled. A conference could then summarize the additional problems of mutual interest.

Need For Improved Sales Techniques

We have made a special effort to talk with representatives of management about this general subject. Although they agree that a more positive approach would be more effective in selling their products and services, they emphasize in defense of their present methods that their representatives in management in general are technical men without training in sales work. If this situation does exist, then they need to borrow salesmen techniques and use them in such a way that the technical people in management could more effectively bring before prospective buyers a realistic picture of their organization potentials. This problem is a common one to research and development groups such as ours.

Ordnance Research Laboratory

The following facts about our group represent the type of preliminary information management should make some effort to obtain before undertaking an active campaign for R/D contracts.

The Ordnance Research Laboratory, established in September 1945 as a department of the College of Engineering and Architecture of the Pennsylvania State University, University Park, Pa., is a research and development organization operating in support of the Bureau of Ordnance, Department of the Navy. It provides the Bureau of Ordnance with an organization through which research and development can be accomplished in an academic atmosphere. As such, its work complements, rather than supplants, that of government-owned laboratories.

The work of the Laboratory is handled through a project organization and covers the gamut of research, development, testing and production engineering. Over one-half of the total effort of the Laboratory is devoted to research and development; the rest is expended on the engineering and production phases of specific weapons and equipment commonly called hardware. For the most part, we tackle scientific problems in the broad field of underwater ordnance. As such, our work lies primarily in the fields of electronics, acoustics, mechanics, hydrodynamics, fluid mechanics and applied mathematics. The Laboratory employs approximately 300 men and women, about 100 of whom hold academic rank in the University.

Divisional Setup

Work is handled through seven divisions; the following is an abbreviated organizational chart. All members of the administrative staff report to the director of the Laboratory, Dr. Gilford G. Quarles, who in turn reports to the Dean of the College of Engineering and Architecture, Dr. Eric A. Walker. Through the dean, director and assistant directors, the Laboratory maintains continual liaison with the Navy Department, while the liaison with the University administration is maintained through the dean's office. Three assistant directors are responsible to the director for the technical operation of the Laboratory. The Research Projects Division, under an assistant director, Mr. Arthur T. Thompson, is responsible for the research and development projects. Its personnel consists primarily of project engineers, each of whom is in charge of a particular project and supported by a group of engineers.

The Engineering Projects Division, under an assistant director, handles problems arising during crucial periods of engineering, early production and proofing of weapons and components developed by the Laboratory. Its personnel consists of project engineers, each of whom serves as a liaison and consulting engineer to the Bureau of Ordnance and the manufacturers of weapons. The Water Tunnel under assistant director, Dr. George F. Wislicenus, is organized on both a project and a functional basis to carry out its dual mission:

(1) To conduct research and development to improve underwater propulsion particularly through the development of a system of propeller design that will result in more effective torpedo propellers.

(2) To provide manpower and facilities for highly specialized work in hydrodynamics in support of other Laboratory projects.

Under its manager, Mr. Robert F. Marboe, the Engineering Services Division is organized on a subject basis to provide the projects of the Laboratory with specialized services. This division, the largest personnel-wise in the Laboratory, is divided into three sections. The Editorial Section is responsible not only for the editing and printing of ORL publications, but also for the operation of the ORL Technical Library. Technical Services Section is divided into groups for chemistry, drafting, photography, machine shops and electronic construction. Field Stations Section provides services at the field stations and the acoustic calibration station. The business manager and his staff perform not only the routine but necessary functions such as purchasing, accounting and property control, but also the rather unusual ones of special procurement, patent processing and security control.

INITIAL CONTACT CHECK LIST

Background information on possible R/D clients helps you fit your facilities into their needs. Here's a check list of what you should know before making initial contact:

- ☐ **The exact name of the organization, its location and affiliates.**
- ☐ **Its purpose, support and physical plants.**
- ☐ **The specific type of work farmed out (research, development, production).**
- ☐ **Who heads the organization.**
- ☐ **The names of key men in each of its divisions.**
- ☐ **The professional status of its personnel.**
- ☐ **Who publicizes its work—as source of information.**
- ☐ **How sponsored projects are initiated.**

Project Birth and Growth

A project within the Laboratory may originate to supply needs discovered by the Navy. Many of our projects, however, originate within the Laboratory itself. In either event the project is discussed, defined and formalized in conference between representatives of the Bureau of Ordnance and our Laboratory and approved by the Bureau of Ordnance. When it is definitely made a part of the Laboratory's program, a project engineer guides it through the four stages necessary for successful completion: study and design, construction, testing and reporting. A staff or task force of engineering specialists assists the project engineer.

To provide office and laboratory space for the program of the Laboratory, the Navy Department has built two well-equipped Laboratories for acoustics, electronics and mechanics research and development. A calibration station in connection with our acoustics work is located on Black Moshannon Lake, 23 miles from the Laboratory. In addition to the facilities at University Park, the Laboratory operates two field stations for its testing programs; one at Key West, Florida and the other at Newport, Rhode Island. A member of the technical staff represents the Laboratory at the Naval Torpedo Station, Keyport, Washington.

It appears reasonable to assume that background information of the above type should be obtained on any agency that contracts R/D projects. Armed with this data, management can begin to ferret those additional facts that will enable it to organize the presentation of its facilities toward the award of a contract. ⌘

As a practical source of energy, the atom was in the realm of speculation as little as ten years ago. Last month earth satellites emerged from their science fiction category. And now utilization of a relatively untapped vast source of energy enters the realm of practicality as R/D engineers and scientists . . .

Turn to The Sun

Charles A. Scarlott

Stanford Research Institute

The sun daily showers the world with several thousand times more energy than man uses. The energy falling in mid-day on an acre of ground in southern United States is at the rate of about 4000 horsepower, roughly equivalent to the power of a large diesel locomotive. The sun pours onto the average housetop in the United States more than a hundred times as much energy as the house receives via the electric power wires.

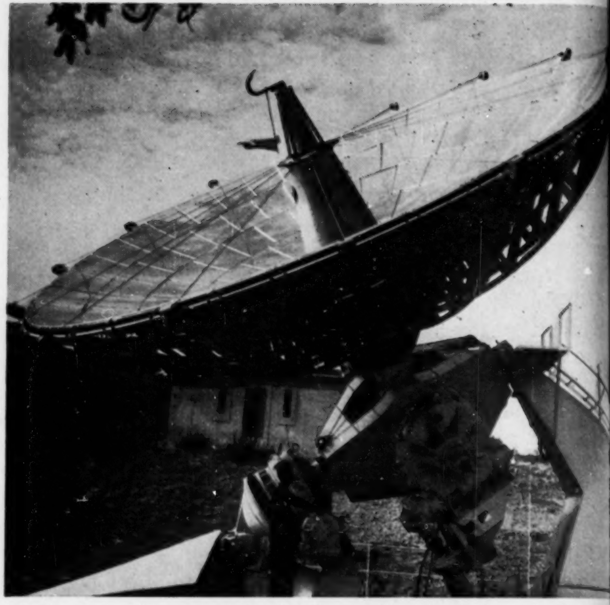
This energy is free for the taking. But the taking is proving to be extremely difficult. Ancient man attempted to make practical use of sun heat. Ponds of sea water were dried to obtain salt and about one and a half million tons of salt are still obtained this way annually in the Middle East. Early history also tells of other uses of solar energy more novel than useful, such as opening temple doors and turning statues on their pedestals.

In spite of today's highly advanced technology, pretty much the same situation still prevails. A few isolated applications of solar energy can be named. But they are small scale for special and limited purposes. Altogether they make no significant impression on the general energy situation.

The difficulty of utilizing energy radiated by the sun is becoming increasingly clear. The simple things have been tried. Much has been learned basically about solar energy in the last decade, and several areas are of sufficient promise to justify extensive technical study and development. However, no satisfactory, economical approach to large scale solar energy capture is in sight.

The Shrinking Energy Stockpile

Unfortunately we can no longer dismiss the harnessing of solar energy just because it is a difficult problem and turn our attention to other things. Examination of the world energy outlook emphasizes that use of energy is rising at an unprecedented rate and that the rate will grow steeper. This is due in part to the rapid increase in population and the general improvement in standards of living. Also many industrial developments are placing new burdens



Forty ton solar oven in Algiers, North Africa, designed Professor A. Guillemonat, synthesizes nitric acid from water, chalk and sunshine. Its 27½ foot parabolic reflec creates temperatures up to 3,000 degrees C.

on fossil fuel supplies. To produce a ton of iron ore co centrate from taconite rock for the blast furnace of a st plant requires at least 50 times more energy than the eas mined, directly usable ore from the dwindling Mesabi p Detergents of fossil fuel origin are replacing soap m from animal tallow and fats. The oil well, not the tree, p vides the raw materials for synthetic rubber. Silk produc from mulberry leaves by worms has been largely supplant by nylon that starts with a lump of coal. Most man-ma fibers and plastics have their beginning in coal, oil or g Replacement of the horse by the tractor shifts an ener burden from vegetation to fossil fuel reserves.

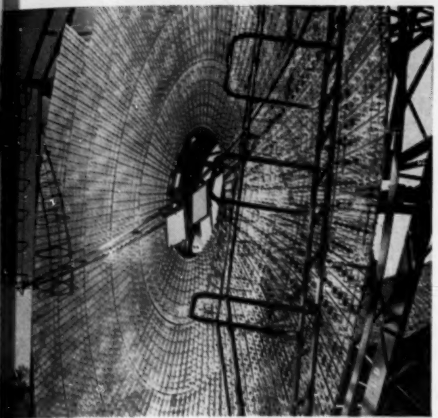
On the other hand, the total lifetimes of various reser of fuel—coal, oil, gas and fissionable materials—are question. However, the differences of opinion center arou the decades of remaining lifetimes of the reserves, whether they number in the hundreds or thousands years.

Nature of Sunlight

If better ways of putting harness on the sun's rays to be found, it is appropriate to ask just what it is we trying to harness. The sunlight we see, the infrared feel as heat but cannot see and the ultraviolet we neither see nor feel are in the same family with alternati current, radio, television, heat and X-rays. All are wav of energy known as electromagnetic radiation.

To human eyes sunlight appears to be smoothly co tinuous, as though it were one thing. The rainbow, ho ever, gives a clue to its real nature—that sunlight consis of light of many colors, extending from a small amount the ultraviolet (as anyone with a sunburn knows) to visible violet, on to the red and deep into the infrared.

Even this concept of the structure of sunlight is enough. Sunlight and all the other forms of electromagne radiation consist of tiny but discrete packets of energy. F example, all red light of one particular color, i.e., one wav length, consists of individual photons of energy of a fix amount. There are no fractional size photons for light



Felix Trombe's 40 foot solar oven on Mont Louis in the Pyrenees is one of the largest applications of solar energy. It is used in production of refractory materials and attains temperatures well above 3000°C.

Drs. W. Gibson and K. N. Mather, directors of National Physical Lab near Delhi, India, inspect fractional horsepower hot air solar engine.

Solar rice cooker at the Goto Optical Lab in Japan is viewed by Paul L. Magill (center), senior scientist at SRI. The 36 mirror apparatus boils water within an hour.

a given color. The shorter the wave lengths, which are those toward the ultraviolet end of the spectrum, the more energetic are the photons. The energy of an infrared or heat photon is much less than that of visible light photons.

Thus we can think of energy from the sun as made up of tiny "bullets" or packets of energy of different sizes depending on their wave length. Those photons that make the 93 million mile trip and survive the hundred miles or so of earth atmosphere strike the molecules of the earth's surface—earth, rocks or the leaves of a plant. Solar energy capture then, involves putting to work the various ways an individual molecule responds when hit with a solar energy "bullet". All solar devices can be conveniently grouped according to these molecular responses.

The simplest response of a molecule to a photon of impinging energy is to reflect it. The molecule may reject the photon instantly. Only the direction is altered in this mirror effect. The molecule and its constituents are not altered by the radiation. The reaction of the molecule to the photon is, in effect, nothing.

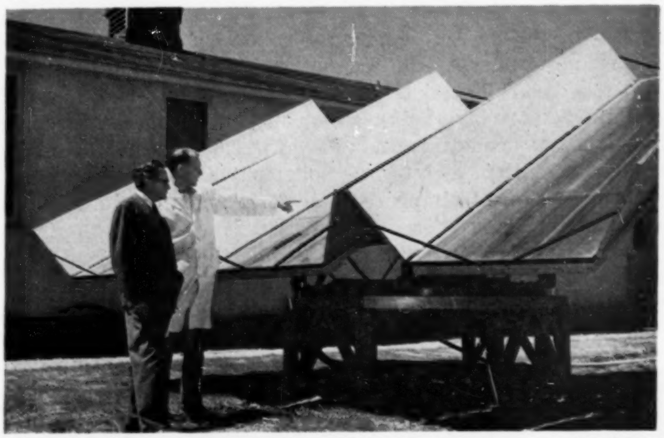
Nearly one third of the sun's rays that reach the earth surface is reflected instantly to the sky, where it is lost forever among the stars. A mirror alone is not a solar energy device. But, as later discussed, it can be teamed with a device operating to convert light to heat to make a solar stove or furnace.

Molecular Motion

The most extensive use of solar energy by man is its conversion to heat. This is accomplished with a second effect of solar photons impinging on earth surface molecules: a photon sets a molecule in motion just as a pebble tossed against a hanging sign moves it a little, either back and forth, or causes it to vibrate. The molecule accepts the energy of the photon briefly, then as it settles back to rest it gives up all that energy. But—and this is important—the energy is released in several bundles of smaller size. The high energy photon of visible light is stepped down or degraded into the smaller infrared photons, i. e., heat. Never are two or more photons converted by molecular motion into a single more energetic one. The conversion is always downhill, towards heat.

The action of molecular conversion of light to heat is the basis of the greenhouse. It is also the principle at work in the flat-plate collector. Light energy passes through the

Author (left) and Dr. Robert Eustis, Manager of the Heat and Mechanics Section in the Physics Department, look at the flat-plate collectors of the solar energy pump built by Societa Motori Recuperi of Lecco, Italy.



Author (left) and Dr. Eustis stand beside operating mechanism of the solar-operated pump. Dr. Eustis points to the pressure gauge at back of heat exchanger. To right of fly wheel is vertical single cylinder engine.

ENERGY DATA

The Sun and Sun Energy

Mass of sun	**= 332,488 times mass of earth**
Apparent diameter of sun	**= 864,000 miles**
Temperature of sun surface, approx.	**= 10,000°F.**
Temperature of sun corona, approx.	**= 20 million°F.**
Temperature of sun center, approx.	**= 30 million°F.**
Solar mass consumed, per second	**= 4 million tons of hydrogen (to helium)**
Total energy release by sun	**= 0.38 trillion, trillion kw (3.8×10^{23}kw)**
Energy reaching outer atmosphere of earth	**= 170 trillion kw (170×10^{12}kw)**
Proportion of sun radiation reaching outer atmosphere of the earth	**= less than one thousand millionth**
Energy reaching earth surface, approximately	**= 85 trillion kw (85×10^{12} kw)**
Solar energy received in United States per year, approximately	**= 9000 trillion kw-hr or 1150 billion tons of coal**

FOSSIL FUEL RESERVES

and Consumption and Energy in the U. S.

Coal—estimated recoverable reserves, January, 1954	**= 937,800 million tons**
production, 1952	**= 467 million tons**
Petroleum—estimated proved reserves, January, 1954	**= 28,946 million bbl**
consumption, 1953	**= 2,932 million bbl**
Natural Gas—estimated proved reserves, January, 1954	**= 211.4 trillion cu ft**
consumption, 1953	**= 9.2 trillion cu ft**
Energy equivalent of fuels consumed, 1953	
from coal	= 12,632 trillion Btu
from petroleum	= 15,912 trillion Btu
from natural gas	= 9,057 trillion Btu
Grand Total	= 37,605 trillion Btu
Electric power generated, 1954	
from coal	= 233 billion kw-hr
from oil	= 32 billion kw-hr
from gas	= 92 billion kw-hr
from other	= 8 billion kw-hr
from water power	= 106 billion kw-hr
Grand Total	= 472 billion kw-hr
Total installed generating capacity, January, 1955	**= 102 million kw**
Electric energy consumed by average residence, 1954	**= 2,540 kw-hr**

cover of glass, which is transparent to short-wave radiation, and is converted into heat energy by the objects inside. The heat is trapped therein because glass is opaque to long-wave radiation, i. e., heat energy.

Flat-plate collectors consisting of one or more layers of glass or other transparent material are placed over some good solar energy absorbing material, with a space between them. The collector is generally a stationary device set at an angle to best receive the sunshine. Air, water or some other fluid is pumped through the space between heat absorber and glass cover. In passage the fluid collects the heat and conveys it to the point of use.

Many ingenious flat-plate collectors have been devised. One interesting form, suggested by Dr. Vannevar Bush, is being studied at Stanford Research Institute. The problems of the flat-plate collector are primarily those of cost. The more or better insulating materials around and under the bed of the collector, the less the heat lost. Also, up to a point, the more layers of glass or other transparent cover used to create dead-air space above the collector the better the heat retention. Flat-plate collectors are deserving of much more effort to improve their form and to reduce the cost of materials used in their construction.

The warmed air or liquid from a collector can be used in various ways. One is for house heating. Several such houses have been constructed, usually with the flat-plate collector as part of the building structure. Heat from the collector is stored by warming water, stones or chemical materials. At night or on chilly days the heat is withdrawn by pumps or fans as needed. In the solar-heated house in Dover, Massachusetts, heat from the collector is blown around cans of a salt that melts at 92° F. and thereby absorbs a large amount of heat for its volume by latent heat of fusion. Several salts, such as sodium sulphate commonly known as Glauber's salt, conveniently melt in th range between 85° and 110° F.

The hot gas or liquid from the flat-plate collector can als be used to drive some form of heat engine to pump wate or to perform some other work. A firm in Italy is sellin solar operated pumps. These range in size from one tent to three horsepower. These are successful devices fo pumping water in sunny, fuel-scarce regions if the temperature of the water being pumped, and also used in th condensing portion of the engine cycle, is relatively coo Pump efficiency falls off rapidly with water warmer tha about 65° F.

The efficiency of any heat engine is inherently limite The maximum efficiency of a device that performs wor by utilizing the difference in two temperatures, such a those of steam and water, is fixed by the ratio of that dif ference in temperature to the higher temperature (usin a scale of absolute or Kelvin temperatures). This is th well known Carnot-cycle efficiency that governs all hea engines. A *perfect* solar engine, then, that receives hea at a temperature of 250° F. above its condensing source o say, 65° has a maximum efficiency of about 32%. Practica considerations cut this at least in half.

Although a heat engine has a definite efficiency ceilin depending on the two temperatures, much can be done t raise the performance within that limitation. Much research and development has been directed to high temperature machines such as internal combustion engines an turbines, but relatively little to improving engines tha operate on small temperature differences.

Efficiency alone is not the criterion of success of a sola device. The objective is to produce energy in a form sui able for the need at hand and at a price that is competitiv with other sources. Efficiency is often important in the cos

$\frac{T_1 - T_2}{T_1} = \frac{185}{710}$

490 645

of energy, but there are many other factors, such as first cost of the equipment, operating expense, maintenance, energy form and storage.

Heat from a flat-plate collector can also be applied to one junction of a thermocouple, which consists of two dissimilar metals with their ends joined. If one junction is hot and the other cold an electric current flows between them. Although thermocouples produce direct-current electricity, they are inefficient. Not more than about four percent, and usually much less, of the energy supplied as heat appears as electric energy. They are subject to inherent limitations of efficiency as are other heat devices. Sun-operated thermocouples are useful for certain limited purposes but the prospect of producing large quantities of electric power with them is poor.

In spite of the problems attending heat devices, the principle of setting molecules in motion by solar radiation is important nonetheless. And the full possibilities of this technique have not been exhausted. For example, it has been found at the Dead Sea solar salt beds that the addition of a small amount of harmless dye to the brine increases the rate of evaporation by a third. This is because the reflection of sunlight by the white salt on the bottom of the beds is substantially eliminated. It has even been suggested that this same idea could be applied by farmers to hasten snow melting in the spring and hence lengthen the growing season. Or, conceivably, a way might be found to store solar heat during the day, as in fused salts, for release in orchards or gardens when frost is imminent.

The possibility of using solar heat to produce large volumes of fresh water from the sea is remote. However, solar stills are practical where the need for water is great, sunshine is in abundance and fuel scarce. The solar still to produce drinking water by aviators downed at sea is an example.

Solar Cooker And Furnace

The two types of molecule reaction to light thus far discussed, reflection and molecule motion, can be paired to provide two other important solar heat devices: the solar cooker and the solar furnace. By using mirrors (or lenses, which accomplish the same thing) the impinging photons are redirected and concentrated onto a small area that converts them to heat.

Several varieties of stoves have been demonstrated. A simple form of stove is being manufactured for sale at about $15 in fuel-poor but sun-rich India. A solar oven designed by Maria Telkes of New York University and consultant to Stanford Research Institute on solar energy uses four flat mirrors to direct the sun's rays into an oven that achieves a temperature of about 350° F.

A few solar furnaces are in operation. The Consolidated-Vultee Aircraft Company in San Diego uses one with a ten-foot mirror for metallurgical research. Professor Felix Trombe of France has a furnace with a mirror 40 feet across. It is used to produce refractory ceramics such as fused quartz and titanium dioxide on a commercial basis. He is building four other, smaller mirror-type furnaces for experimental use. A furnace of different design with an aluminum reflector 27½ feet across was built by the government of Algeria to produce fertilizer by fixation of nitrogen in the atmosphere.

Solar furnaces are relatively efficient, converting upwards of 70% of the total incident radiation into usable heat. Temperatures above 7000° F. have been obtained. The solar furnace provides a readily controllable means of obtaining extremely high temperatures and is a useful tool for several applications. However, it produces heat only when the sun shines and requires a mechanism to keep it focused well on the sun. The initial cost is comparatively high.

Electron Disturbance

A third type of response of a molecule to light energy is the disturbance of the satellite electrons from their normal orbits. When the molecules of certain substances receive light energy, some of the electrons spinning around the nuclei of the atoms are boosted into orbits farther out. Eventually—in a time that may be as short as a millionth of a second or as long as several hours—the electrons fall back into their original orbits. They almost never do it in a single jump, but in a succession of steps. At each step a photon of energy, smaller than the original, is emitted. Thus the color of the light emitted differs from the incident light. This is phosphorescence, so called because phosphorus is one of the more common substances that behaves this way.

Phosphorescence is an interesting way of storing light energy briefly. While it has some limited applications, it is not regarded as having any prospect as a major energy device.

Potentially of much greater significance is a fourth way of operating on the molecule with sun energy. When the atoms of certain molecules are hit hard enough, some electrons are jolted entirely out of their orbits and away from the parent atom. Once out in the open they create an electric potential that causes a direct electric current.

This is the principle of the photographer's exposure meter. While it is an extremely useful device, it is inefficient. It converts only about two tenths of one percent of the received light into electric energy.

Silicon Solar Battery

A much more attractive photoelectric power source is the silicon solar battery. One has been demonstrated by Bell Telephone Laboratories. The announced efficiency is eight percent, but improvement can be exepected. However, the silicon cell has a ceiling efficiency of about 22% because most solar photons (those in the infrared) are too weak to dislodge electrons from the silicon surface. Much of the sun's radiation is simply wasted as heat or is reflected. Also the energy to lift an electron away from its normal orbit around a molecule nucleus is a specific amount. Surplus

Solar Energy Received At Selected Cities, Average

	BTU Per Square Foot Per Day	KW-HR Per Square Foot Per Day	Million Kw-Hr Per Acre Per Year
Boston, Massachusetts	1110	0.336	5.18
Cleveland, Ohio	1312	0.385	6.12
El Paso, Texas	2037	0.596	9.50
Fresno, California	1670	0.489	7.79
La Jolla, California	1526	0.446	7.02
Las Vegas, Nevada	1822	0.534	8.49
Lincoln, Nebraska	1354	0.397	6.32
Miami, Florida	1497	0.439	6.98
New York City	1054	0.308	4.92
Salt Lake City, Utah	1442	0.420	6.73
Seattle, Washington	1160	0.340	5.41
Washington, D. C.	1234	0.361	5.76

energy is spent needlessly accelerating the electron. The energy left over from one photon cannot be used to partially dislodge another electron. Hence, not all the energy of the more energetic photons toward the violet end of the spectrum can be used.

Perhaps an eventual efficiency of some 15% can be expected for a practical silicon battery. That is pretty good, because it is a direct conversion device without moving parts, requiring no attention. Indeed, the performance of the present silicon battery is good enough for the device to be practical for many purposes where small amounts of energy are adequate and where continuity is not essential.

Further research on the principle of photoelectricity is definitely worthwhile. Materials other than silicon may be found that are less costly or more efficient converters of solar to electric energy—preferably both.

In all the ways of using solar photons discussed thus far the molecular structure has remained intact. As outlined, the molecule may be set in motion, the satellite electrons of its atoms may have been disturbed or dislocated from the atom, but the location of atoms in the molecular structure has been unaffected. But there are ways of using solar energy to cause molecular changes that are of greatest importance energy-wise. They are, indeed, the means by which we remain alive. They are the source of our food. Also our oxygen. Plants and simple animal forms use the energy of sunlight to effect molecular changes.

The best known reaction of this sort is the use of solar radiation by chlorophyll to convert water and carbon dioxide into carbohydrates and oxygen. The general steps of chemical reaction are well understood. The reaction can be easily written as carbon dioxide plus water plus 112 kilocalories of energy is converted to carbohydrate and oxygen. This is photosynthesis, which is accomplished by chlorophyll, a basic substance to all living plants. Chlorophyll has been isolated and studied but science has not succeeded in synthesizing it.

Research on Photosynthesis

How chlorophyll is able to make carbohydrates and oxygen out of water, carbon dioxide and sunlight is a mystery. It has been the subject of long research in many parts of the world. Only recently has come the work of a group of scientists at the University of California identifying the steps by which the reaction is accomplished. For, in steps it must be. How a reaction requiring 112 energy units can be effected with photons having only about 40 to 60 units of energy is the puzzle. Scientists have not been able to combine the effect of two or three photons to do the work of one big one.

Photosynthesis, for all its importance, is not an efficient converter of sunlight into chemical energy. Most scientists believe that it is in the neighborhood of 25%. And even that is utilization of the total light falling on the plant and is achieved only under the best laboratory conditions, almost never in open fields. In the fields and forests the conversion is much less, considering that the energy in the infrared spectrum (about half the total) is not used, that much of the energy falls on bare ground between the plants, that the growing season is only a portion of the year, and so on. The conversion for even the best plants, such as sugar beets, is about two percent. Most farm crops use about one half of one percent of the light that falls on the field.

Photosynthesis is also accomplished by simple plant forms such as algae and by the phytoplankton of the sea. In particular the green unicellular algae chlorella has commanded a great deal of research attention and offers considerable prospect of producing both food and fuel. This technique has much to recommend it. Chlorella can be grown in a water solution on a continuous basis. The proportions of carbohydrate, protein and fat in the end product can be varied widely. If chlorella could be grown in large quantities with the same yield as in laboratory culture, the result would be 20 tons of protein and 3 tons of fat per acre per year, which far exceeds the possibility with land plants. This would be an efficiency of nearly 20%. But no one has succeeded in doing this yet. There are many unsolved problems of proper turbulence of the water containing the algae (sunlight is too strong for continuous exposure of the algae), most suitable temperature, carbon dioxide supply and development of disease-free strains of chlorella.

Radiant Energy For Water Dissociation

While scientists have not yet copied the photosynthesis reaction, they have great hopes of using solar energy to perform a different type of energy storing chemical reaction. Of great fascination is the possibility of breaking up water into its constituent hydrogen and oxygen for later recombination to recover the energy.

Several reactions by which water is dissociated by radiant energy into oxygen and hydrogen are known. Dr. L. J. Heidt, at MIT, has been experimenting for several years with the chemical decomposition of water containing ceric perchlorate and perchloric acid by ultraviolet light. The reaction does not seem to lend itself to general use as a means of capturing solar energy, however, because it uses only a relatively small part of the sun's rays.

Scientists of Stanford Research Institute are studying a different reaction for breaking water into its components. In this reaction a solution containing water, an inorganic chemical and a small amount of chlorophyll as catalyst is exposed to sunlight. The products of the reaction, again, are oxygen and hydrogen. It is too early to state what success will be achieved. However, the reaction in theory is attractive because it can use almost all of the visible spectrum of sunlight.

Use of sun energy to effect the rupture of water molecules is promising and justifies major research effort. Water is readily available as raw material. If it can be inexpensively and efficiently dissociated into oxygen and hydrogen the troublesome problem of energy storage would be solved. Hydrogen could be conveniently stored as a gas and the energy recovered by burning, releasing heat and forming water. The temperature of burning oxygen and hydrogen is extremely high—too high for present known heat engines. Effective utilization of these temperatures to produce mechanical or electrical energy would entail further research and engineering effort.

Also there is prospect of recovering the energy directly as electricity without going through the wasteful heat cycle or the use of moving machinery. Experimental cells exist for doing this. In one, the Bacon cell, hydrogen and oxygen are introduced through porous walls enclosing a liquid electrolyte. Therein they recombine to form water and electric current without the production of significant amounts of heat. Extremely high efficiencies of these small, laboratory cells, 50 to 65%, are reported. Additional work on cells such as this appears definitely to be in order.

The attack on the problem of solar energy capture is gaining momentum. While the obstacles are formidable, the rewards for accomplishment are great. It is probable that success is mandatory. ∎

NBS Studies Stark Rubber in Basic Research on Crystallization Properties of Polymers

WASHINGTON, D. C.—To obtain information which may serve as a guide in the preparation of new types of polymers, the National Bureau of Standards is conducting a basic research program on the crystallization properties of polymers and their correlation with molecular structure. A recently completed phase of the program dealt with the nature of stark rubber.

The physical properties of polymers and their ultimate end uses as rubbers, plastics or fibers depend greatly on the presence or absence of crystallinity and on the melting temperature. Many plastics and fibers would be rubbers if they were not crystalline at ordinary temperatures; actually these materials do become rubberlike above their melting temperatures. On the other hand, many rubbers owe their strength to the development of crystallinity on stretching. Yet rubbers that develop appreciable crystallinity on cooling tend to lose their elasticity and extensibility at low temperatures.

The term "stark" is applied to those occasional specimens of natural rubber which are hard and inelastic after prolonged storage in temperate climates due to the development of appreciable crystallinity. Perhaps the most unusual property of stark rubber is that its melting point is considerably higher than that of ordinary rubber. However once melted, stark rubber thereafter melts at the lower temperature and otherwise behaves like ordinary natural rubber.

The anomalous melting behavior of stark rubber has long been an obstacle to more complete understanding of the thermodynamics of polymer crystallization. To find out how stark rubber is formed and the reasons for its high melting temperature, the Bureau investigated the melting behavior and X-ray diffraction patterns of four stark rubber samples from widely different sources. These were found to have melting temperatures in the range from 39° to 46°C, as compared to a melting point of 28° for natural rubber crystallized by cooling only.

The melting behavior of the stark rubber also differed in other ways from that of ordinary natural rubber and other polymers. In the temperature interval from about 35° to the melting temperature, the specific volume increased very slowly under isothermal conditions. Yet the total volume change at a given temperature was appreciable. This necessitated raising the temperature of the samples very gradually. Thus the total heating process for a typical determination of the melting temperature took 50 to 100 days.

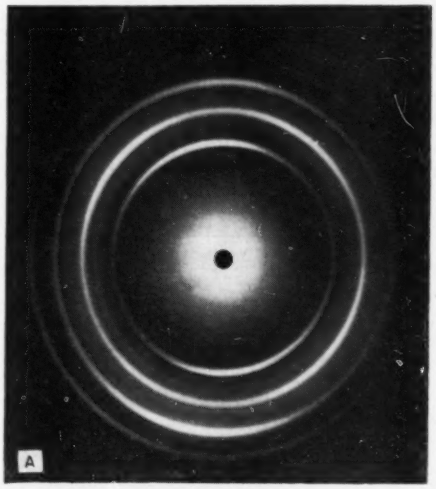
X-ray diffraction patterns obtained from the stark rubber samples at room temperature gave a rather clear indication of the basis for the observed crystallization behavior. Though the diffraction haloes corresponded to the spacings observed in natural rubber that has crystallized either by cooling or stretching, the intensities of the diffracted X-rays around the circumference of the rings were not uniform. This result indicates a preferred orientation of the crystallites as compared to the random orientation observed in systems where crystallization is induced solely by cooling. Because the crystallites are oriented, the amorphous regions that connect them must also be oriented to some extent. In such an oriented system there are two possible explanations for the higher melting temperature. If the orientation is maintained on fusion, the melting temperature will be raised because less entropy is gained on melting relative to the unoriented system. Alternatively, at an appropriate temperature the oriented amorphous regions can rearrange themselves to their new probable configurations, and the crystallites will become unstable and melt. The latter behavior is more likely in the case of stark rubber, since normal crystallization behavior is observed after the initial melting.

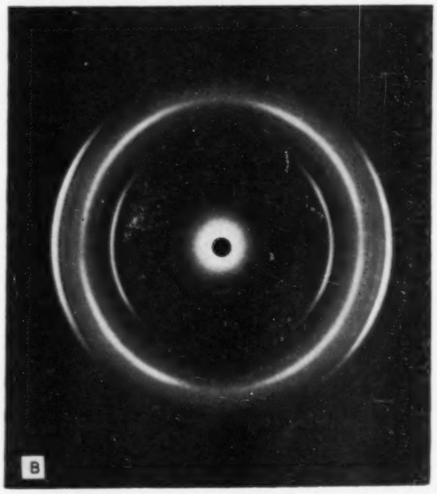
The orientation in stark rubber is probably due to the original plantation processing. After coagulation of the latex, the amorphous rubber is rolled into sheets which are stacked one upon another. The bale of rubber is then subjected to a rather large simple compressional stress, which probably can cause the amorphous segments to be preferentially oriented; the high viscosity of natural rubber enables this orientation to persist for long periods of time at the usual storage temperatures when the external stresses are removed. Orientation of the chain segments, in turn, facilitates crystallization at temperatures where crystallization is prohibitively slow for undeformed rubber.

In principle, other crystalline polymers could display this same melting behavior. In stark rubber the high viscosity of the amorphous material allows orientation of the chain segments to be maintained for relatively long periods of time in the temperature range of interest whose lower limits are set by the equilibrium melting temperature of natural rubber. As long as the equilibrium melting temperature is sufficiently low, as in the case of natural rubber, for the rate of amorphous rearrangement to be slow, this phenomenon should be observed.

Orientation during crystallization is essential in preparing stark rubber in the laboratory under controlled conditions. Crystallization should occur while the rubber is being deformed. When the external stresses causing the deformation are removed, the orientation will persist at temperatures above the equilibrium melting temperature of natural rubber.

NBS observes volume-temperature changes in stark rubber by containing samples in small volume dilatometers held at constant temperature within the two glass jars. Changes in volume are observed as the displacement of a mercury meniscus within a capillary tube connected to the dilatometer.





Typical X-ray diffraction patterns of stark rubber specimen at room temperatures shows preferred orientation of crystallites by nonuniformity of some of the rings. A: Naturally occurring sample. B: Sample prepared in laboratory.

Book Reviews

What Makes An Executive?

ELI GINZBERG
CHAIRMAN ROUND TABLE REPORT

Reviewed by Richard G. Kopff
Arma Division, American Bosch Arma Corporation

Here is an unusual report on executive potential and performance recorded during eight meetings of 17 top-flight executives and specialists. Its fascination lies in its insights into the subjective evaluation by these men of their own jobs, how they view the young and middle aged men in their organizations, what they have done to train and develop men coming up the ladder and how they view executive performance.

The first two meetings identified major problem areas: origins of executive potential and values and limitations of a college education. The third treated factors that might shed light on potentialities of future executives. Subsequent meetings considered development of future executives, evaluation of executive performance, the executive and the organization and guidelines for future policy and research.

The report can have a lot of meaning to a discriminating reader, but it offers no panacea. One of its values is its clear indication of the complexity of the problem of identifying and developing executives. At the concluding session, one member said:

"No pattern of development has really appeared. There were many ideas about what could or should be done. But the thing that I got out of the discussions was that the size and scope of one's operations definitely affect what one should do in a training program. For instance, General Electric has gone much further than smaller companies. I would rather pick a pattern for my own kind of company than conclude there is any general overall recommendation which would fit all different types of businesses."

The discussions were remarkably frank and apparently well-reported. In discussing how one recognizes a leader, one participant said: "I really don't know how we find the natural leaders. I suppose mostly by smell. However, I would not want to deny that there is an element of patronage and pull there as everywhere else."

There is an understandable lack of material on specific problems of the executive in research and engineering. The approach of the Round Table was broader. One member who had spent most of his life in an industry which had seen rapid technological advances noted that his company had hired many engineers and chemists. He stated, "a fellow who came up the ranks became educated in human problems, but the technicians are not. We have a problem of converting these technicians into good all-around managers."

Another member added: "I am frightened to death by the so-called engineer shortage. We are starting young men with very high salaries. What will happen in a few years, when they won't be making very much more than when they started?"

Throughout the discussions there was only the barest hint of the need for adequate technical training Apparently the participants are too high up on the management ladder in very large corporations to recognize clearly the needs of the engineering executive. It was continually emphasized that a college degree is important only in getting a job, but that it loses its importance after perhaps ten years. It was admitted that degrees serve as a screening device. This seems to be more than a slight distortion when it concerns the chemical and electronics industries, where technical know-how is of prime importance in fulfilling the corporate purpose. In insurance, production, food manufacturing and distribution, banking, utilities and the like, a general arts background may be helpful for "development", but it is difficult to understand what could possibly substitute initially for technical competence in law, medicine, engineering and the sciences.

One observer perhaps put his finger on the issue when he attempted to distinguish between great men and leaders:

"I think a scientist can be a great man just by being a scientist, but I think a leader must be an executive. He must have certain executive qualities to lead people along certain lines. Even a scientist, if he is going to be a leader, must have certain executive qualities."

Another pointed out the fallacy of trying to make a manager out of a good contributor. "A good engineer", he observed, "is not necessarily a good manager of an engineering department."

There seemed to be a general recognition of today's problem of finding an adequate number of capable executives, and a realization that the problem will not solve itself. Important to all engineering executives was the feeling of the group that technically trained men find it difficult to succeed in managerial work. The Round Table noted that whatever their technical competence, technically trained men will probably find it difficult to cope with the intangible but important facts of business.

In this review discussions ranging around specific evaluative techniques and training programs have been avoided. First, the material has to be read in context for its complete meaning. Second, no firm conclusions that lend themselves to summary treatment came out of the Round Table. The discussion presenting the various points of view furnishes its own stimulus and deserves careful reading and evaluation in terms of the specific needs and problems of individual companies.

Columbia University Press. New York. 179 pages, $3.50.

A Policy for Skilled Manpower

BY NATIONAL MANPOWER COUNCIL

Reviewed by John W. Cook
Manager, Applied Physics Department
Burroughs Corporation Research Center

The need for skilled manpower in the United States is increasing rapidly. Greater learning and understanding are required of persons participating in skilled jobs in industry today. This book, summarizing many discussions on all phases of the problem, lists a number of recommendations to be followed in designing a program to increase the skilled manpower pool. Unfortunately, there are few new ideas and concepts presented. Instead, facts known for many years are reiterated, and the growing need for an active attack on this problem re-emphasized. A large part of the book discusses difficulties in educating personnel so that they may accept responsibilities in the skilled category and the best means of preparing a person to do a specific job. It is indeed heartening to see recognition given to general education as opposed to more vocational training. The educational system in the United States is shown in this study to be markedly deficient in many respects. It is apparent from reading the second part of the book that, regardless of the reasons underlying the lack of training of skilled personnel, there is a definite trend toward a hurried, incomplete and inadequate train-

ing program. The data quoted on students in the older skilled crafts such as carpentry and furniture making clearly shows the educational system to be trailing the manpower need significantly.

The problem of the employer and the method that he uses for evaluating personnel are well presented. This again points up the discrepancy between the training and the responsibility level expected by employers. Basically, the educational program followed in this country is not keeping pace with the demands of industry.

The book is well written and contains a reasonable abstract of much basic material. It does not indicate mechanisms by which the cited problems may be solved, but simply considers the current status of various attacks on the problem. It is worthwhile reading for those confronted with general problems in obtaining or developing skilled manpower, but will probably seem unnecessarily lengthy to those searching for solutions to educational problems.

Columbia University Press, New York, 292 pages, $4.50.

Servomechanisms and Regulating System Design, Volume II

BY H. CHESTNUT AND R. W. MAYER

Reviewed by John Hovorka, Staff Massachusetts Institute of Technology

The stated purpose of the authors of this volume is to provide "the design steps required to convert the control system parameters into suitable hardware terms". Volume I of this set, published in 1951, was a servo textbook; the present volume is an encyclopedia of design methods containing complete, authoritative and accessible information.

Completeness in a book of this kind is relative to the state of the art, and the field of servos is growing rapidly. However, much basic information has been reduced to formulas since the appearance of Volume I. It is fortunate that the formulas exist. With their aid the authors are able to go step by step through the design of servo loops for various purposes, taking up drive systems, attenuation frequency control and amplifier design, in that order. The first two chapters detail pertinent measurements and design objectives, and the last three chapters deal with nonlinear components in servos. Alternating-current servos are the subject of a separate chapter.

The book is authoritative as well as complete in the sense that the author's own problems and their solutions are used as models. The consequent restriction of specific detail to certain fields, notably radar, is offset by the broad applicability of the problem types discussed.

There are two practical approaches to an encyclopedic work on the part of the person using it: through the index and through the table of contents. In the present volume, the index could stand improvement. The entry "Variable gain" should refer to the same pages as "Gain, variable" for instance, and such entries as "Capacitor, size of" are certainly best omitted. On the other hand, the Table of Contents is the best way into this book. The chapter and section headings are simple, highly descriptive and in general well chosen. In fact, if modified slightly and arranged alphabetically, they would make a good index. But, in the main, the book is the well recorded experience of its authors and deserves a place next to Volume I on the reference shelf.

John Wiley and Sons, Inc., New York, N. Y., 384 pages, $8.50.

Information Processing Equipment

M. P. DOSS, EDITOR

Reviewed by Vernon H. Van Diver Consultant Industrial Marketing

The capabilities of different kinds of equipment, approximate rentals or prices and commercial sources of supplies and services are catalog details ordinarily obtained after time consuming research. This timely volume not only hastens preliminary work in the quest for such data but also presents what is not available in the manufacturer's literature: the advice of specialists whose informed appraisals and comparative analyses are otherwise secured only by engaging specialists. Here is a book that will definitely save one from starting a data processing job from scratch and duplicating work already done more efficiently.

The book contains ten files leading interestingly and informatively from the making of a few copies of a report and copying a diagram through progressively more complex problems such as storing a million "bits" of data on a single magnetic drum, with any "bit" accessible in less than a second. They were contributed by 16 experts who prepared them originally for a symposium entitled "Equipment for the Preparation, Reproduction and Utilization of Technical Information" arranged by the American Chemical Society in 1953. Together they comprise one of the most comprehensive topical files yet published.

Mr. Doss is well situated to understand the value of guidance which saves repeating yesterday's mistakes and trying to discover or engineer things already in practice. His is the Texas Company. His is a group continually exploring frontiers: the research and technical department. Where more so than in this highly competitive field is the generation of technical knowledge multiplying rapidly? Where are there fewer avenues by which to escape the essential fact that every company intending to hold or advance its position must, sooner or later, have its engineers well informed on equipment commercially available for processing all manner of information?

This series of topical files is skillfully edited to the engineer level, containing exactly what the engineer wants to know—neither more nor less.

Reinhold Publishing Corp., New York, N. Y., 270 pages, $8.75.

Conduction Heat Transfer

BY P. J. SCHNEIDER

Reviewed by J. W. Westwater Associate Professor Chemical Engineering, University of Illinois

Much thought has been given to the science of heat conduction since the first treatise by Fourier in 1822. This book, like Fourier's, is intended as a treatment of heat conduction but is necessarily rich in mathematical detail.

A good review of the mathematical tools is given, including Fourier series, Legendre polynomials, Bessel functions, La Place transformations and gamma functions. The simpler mathematical concepts such as hyperbolic functions and the error function are assumed to require no review.

For the worker competent in the required mathematics, this book is valuable both as a reference and as a text. Eight chapters are devoted to steady-state conduction. One of these is an interesting nine page discussion of heat transfer in porous solids. Three chapters are devoted to unsteady-state conduction. One-directional and two-directional conduction are considered in great detail. The three-dimensional case is considered slightly. Although analytical methods are used where possible, numerical, graphical and experimental techniques are not neglected.

The final chapter is an excellent discussion with illustrations of the analogies between heat conduction, streamline fluid flow, electric current flow and deformation of an elastic membrane.

Inasmuch as the author is a mechanical engineer, the profuse examples and problems are naturally slanted in interest. Turbine blades are chosen to illustrate the fin formulas; cylinders of an internal combustion engine are used for problems in periodic heat flow. This viewpoint should be refreshing to physicists and chemical engineers familiar with older, well-worn examples. The author is "modern" in that he includes a consideration of heat con-

duction in a nuclear reactor. A typical problem is solved using circular harmonics.

The format is quite pleasing. On the debit side is the lack of nomenclature. Tabuated physical and thermal data are sparse; thermal conductivity, heat capacity and thermal diffusivity are given for ten metals only. On the other hand, mathematical tables for such items as Bessel functions and Legendre polynomials are plentiful, occupying twenty-two pages.

The book should be in the library of any technical organization faced with problems in heat conduction.

Addison-Wesley Publishing Co., Inc., Cambridge, Mass. 395 pages, $10.00.

Motivation Research: A New Aid to Understanding Your Market

HANS A. WOLF, EDITOR

Reviewed by Dr. A. Melvin Gold
Institute for Motivational Research, Inc.

The mere publication of a volume on the subject underscores the potency of Motivation Research as a factor in business today. This is not a "big book" with overwhelming facts and figures, nor is it a panacea for the problems and ills confronting business and advertising. It is a concise, simply done volume that indicates a direction and answers some questions.

The authors, a group of students in Prof. George F. Doriot's course in Manufacturing at Harvard Business School '54-'55, demonstrate in Part I, Motivation Research Today, that although its methods are generally given prime billing, Motivation Research is first and foremost the use of basic theories and generalized observations developed by social scientists about the how and why of individual and group behavior in society.

This astute group does not pull any punches in presenting a critical evaluation of the successes and limitations of Motivation Research. As an infant in the field of business and advertising research it can be mismanaged, but, handled properly, it can also "evaluate a finished product policy and promotional strategy . . . and aid in forecasting general market conditions by adding knowledge on consumer intentions to statistical data about economic conditions." It studies the psychology of the consumer and forces which shape his buying, thus helping the business man fully understand his market.

The writers question the widespread interest in this topic. The answer is easy. There are more competitive market conditions today, the consumer has more money to spend, Motivation Research is new and has already answered some interesting and complicated questions. Acceptance of M.R. shows that there is a trend toward more scientific business management. However, there is also resistance, as there is to anything that disturbs the status quo. But as "king sampling theory" won its battle twenty years ago, Motivation Research is winning its battle today.

Very impressive and meaningful is the research this group did among sales executives and members of the Advanced Management Program at Harvard in the spring of '55. In part the results show that many studies have been made on Motivation Research in companies whose annual sales exceed fifty million dollars. Small firms unable to undertake the full costs at present, would band together for cooperative studies. Executives from large organizations expressed interest in Motivation Research as a direct aid in presenting their sales message to customers either through advertisements or salesmen.

Part II of the volume, Motivation Research Tomorrow, develops such ideas as the continuing need for Motivation Research, the obstacles it must overcome and the training of personnel. The writers firmly assert that this new discipline is experiencing growing pains. New products and changing consumer attitudes will continue to provide Motivation Research with a plethora of studies in the future. They propose that there be courses given in this area to social scientists and business majors alike in colleges. They feel, and substantiate their belief, that with the theoretical advances made in the schools today and their applications to business, Motivation Research will become a rigid discipline and find for itself a niche in tomorrow's business world.

The present role of Motivation Research enables the business man to understand his market and attain his goals. The future depends on the wedding of the social scientist with business after a long courtship. The social scientist must understand and accept the problems of business; business must sit down with the social scientist and learn the newer techniques of gathering and assessing information.

Motivation Research Associates, Boston, Mass., 80 pages, $10.00.

Patent Law in the Research Laboratory

BY JOHN K. WISE

Reviewed by Elton T. Barrett
President, CGS Laboratories, Inc.

This accurate, informative and interesting volume includes an excellent synopsis of the history of and reasons for our patent system. A major portion of the book discusses the procedure by which a patent is obtained; only the last eight pages are devoted to laboratory records.

The book is of doubtful utility to one directing efforts of research or development groups. Some understanding of the history of patents and a cursory knowledge of procedures for patent applications in the Patent Office may be interesting, although not directly useful to a director of research and to engineers generally. Such information may, however, make the research director more tolerant of the delays imposed by the requirements of the patent attorney in connection with the keeping of records in the laboratory.

Not intended to serve as a guide for anyone actually prosecuting patent applications, Mr. Wise's book would be inadequate for this purpose. The research director who desires to establish a practical program for protecting the patent rights resulting from research and development work carried on in his laboratory will find it necessary to study one of the many books dealing with the more practical aspects of protecting inventions, or even better, to consult a qualified patent attorney to design a practical system for his special needs.

Within the scope of his book, Mr. Wise has expertly presented an overall summary of the patent system. He has pointed out the inroads on the patent system made by the courts and the difficulty of making the courts understand the reasons underlying our patent system. The book also imparts some understanding of the complex procedures involved in obtaining a good patent.

Reinhold Publishing Corp., New York, N. Y. 192 pages, $2.95.

NBS Circular Summarizes Leather Research Projects

"Leather Research and Technology at the National Bureau of Standards" summarizes typical NBS leather projects: establishment of optimum pH of 3.0 below which leather is not stable during storage; a method for quantitative determination of amino acids in collagen; measurement of size and distribution of pores in leather; methods of impregnating leather with polymers; measurement of physical constants of leather and other polymers; investigation of tanning properties of synthetic organic compounds; and design of special equipment for laboratory evaluation of performance.

The circular also contains a comprehensive list of publications by members of the Bureau's Leather Section on collagen, leather and other polymers.

NBS Circular 560, 13 pages, $.15. Order from U. S. Government Printing Office, Washington 25, D.C.

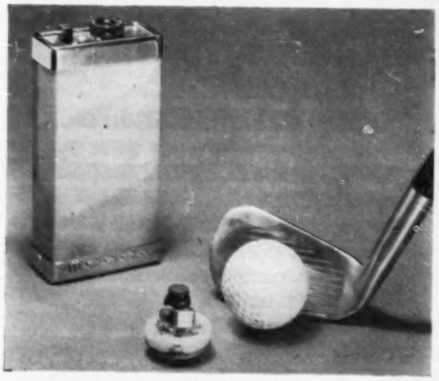
Serendipics

FORE!—The Modern Way

Latest in the way of inventions to ease the burdens of modern man is a non-loseable "golf ball" used by Dan Noble, vice-president of the Communications and Electronics Division of Motorola, Inc. To demonstrate the possibilities of the transistor, Mr. Noble had Motorola engineers produce a complete broadcasting set using a standard transistor. The set was designed to fit inside a plastic "golf ball" just about the size of a regulation ball.

Despite its size, the unit transmits a sufficiently strong radio frequency signal that can be picked up by a portable, pocket-size receiver carried by Mr. Noble. By merely rotating the receiver as a direction finder, he can easily determine the location of the lost "electronic golf ball".

Mr. Noble stresses the fact that this "electronic golf ball" is strictly a gadget which readers should not expect to find in their sporting goods store. But for those golfers whose method of scoring the game is to count the number of balls they lose per nine holes, it is something to dream about.



Pocket-sized receiver picks up signals from miniature transmitter inside golf ball.

SPCA Research *(Society for the Prevention of Cruelty to Anglers)*

Florida sports fishing enthusiasts may well find the fishing better in their favorite lake or river in the near future as a result of a research project now underway. The University of Florida reports that scientists at the Engineering and Industrial Experiment Station, working under a grant by the Florida Game and Fresh Water Fish Commission, are devising means of ridding Florida waters of "rough" fish by electricity.

These studies and experiments are a result of constant complaints from fishermen who have found that "rough" lake fish, such as gar and shad, seriously impair sports fishing by using up needed food and oxygen.

To conduct the necessary research, project personnel have constructed what is probably the largest tank of its kind ever built. Measuring 18 feet long, seven feet wide, and four feet deep, the tank has a waiting room as well as an electrocution chamber.

The waiting room holds fish in reserve; the electrocution chamber is used for testing. The outer wall contains three large observation windows.

Over a hundred large "rough" fish, supplied by the Game and Fresh Water Fish Commission specifically for the project, can be kept in the reserve chamber while fish are being electrocuted in the other. Insulating the reserve tanks against electricity is a six-inch, steel reinforced concrete dividing wall, covered with six coats of waterproof and insulating paint.

The fish are killed by screen electrodes which are placed in the testing side so as to form a box with two sides serving as electrodes and two sides as walls. And research personnel try to get the fish to cooperate in their electrocution by having them line up perpendicularly to their screens. In this way, the jolts of electricity are passed from one electrode to the other and a larger area of the fish will be affected.

One three-foot gar fish was hit so hard by a jolt of electricity that his neck was broken. Two gars, also in the same experiment, died later while the fish in the reserve tank only 90 inches away swam lazily awaiting their turn.

Research personnel believe that the principle can be applied to removing such fish from Florida's lakes and streams in a like manner. It is known that certain types of fish can be drawn to a point by trailing two electrodes in the water. And, the larger the fish, the greater the attraction.

Dr. James B. Lackey, project leader, still won't venture a prediction of guaranteed results because of a considerable amount of research yet to be done. But, with the tank at the University and field work in the Lake Okeechobee area, the project is receiving strong backing from sports fishing groups.

Well, That's Done—The Rest Is Up To The Rocket Engineers

A "space clock" that provides a preview of products which the instrument industry will be called on to create in the age of interplanetary travel will be exhibited at the 10th Annual Instruments and Automation Conference and Exhibit to be held at Shrine Auditorium and Convention Hall in Los Angeles, California, September 12 to 16. Dr. I. M. Levitt, Director of Fels Planetarium of the Franklin Institute of Philadelphia, conceived the "space clock" and made the astronomical calculations for it. Mechanical design was by Mr. R. B. Mentzer, assistant director of research in charge of process development at Hamilton Watch Company, Lancaster, Pennsylvania.

Hamilton Watch Company made the clock to demonstrate interplanetary time differentials which future space travel pilots must consider in planning trips to Mars. The space clock indicates Mars time (outer dial) and Earth time (bottom dial). Two other dials give calendar dates on Earth (right center dial) and on Mars (left center dial). The "calendar" dial for Mars is based on a year of twelve months, but the Mars month has up to 56 days, which are 24 hours, 37 minutes, and 12 seconds long.

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D. C., unless another source is stated.

Research Reports

Aircraft Instrumentation

Four reports of research conducted for the Air Force to determine the most desirable types of instruments for certain applications in aircraft have been released.

The first presents an integrated survey and interpretation of psychological research relevant to the design of counters for use on airborne equipment. The merits and demerits of a counter as compared with other methods of presenting information in typical applications are discussed. Such design problems as the speed and direction of rotation of a counter and the location and mode of operation of its associated control are analyzed in detail.

Counters for Airborne Use, *PB 111564, 13 pages; $.50.*

The second report summarizes a series of experiments designed to investigate the effects of certain control-display relationships on making settings with moving-scale display relationship. Recommendations are made for the application of moving-scale assemblies.

Desirable Control-Display Relationships for Moving-Scale Instruments, *PB 111649, 26 pages; $.75.*

Investigations of minimum observable change in brightness as a function of the original adapting brightness, and the duration of the change are discussed in the third report. Results show that a very weak signal on a cathode ray tube screen may be detected if it persists long enough to allow the eye to integrate the energy emitted.

Foveal Luminance Discrimination as a Function of the Duration of the Decrement or Increment in Luminance, *PB 111599, 20 pages; $.50.*

The final report reveals that the choice between the eyes and ears as sense channels for the presentation of information to the human operator rests upon the specific demands of various operational situations. The stimulus properties of light and sound differ, and the receptor characteristics of vision and audition also differ. It is possible, by matching these distinguishing sense characteristics with specific demands of particular situations, to suggest some "division of labor" between the two sense channels for purposes of data presentation. Principal categories of demands are proposed.

A Comparison of the Visual and Auditory Senses as Channels for Data Presentation, *PB 111651, 44 pages; $1.25.*

Deposition of Salts From Freezing Sea Water

The order of precipitation of salts when sea water freezes has been investigated by the University of Washington, Department of Oceanography, under Navy contract.

It was found that about 88% of the water is transformed into ice before the first salt crystallizes. The first salt formed is sodium sulfate decahydrate which begins to separate at —8.2°C. At —22.9° sodium chloride dihydrate precipitates in large quantities, and the concentration of sodium in the brine decreases rapidly. There is a decrease in the concentration of potassium and magnesium below —36° when potassium chloride and magnesium chloride dodecahydrate precipitate. Tests were limited to —40°C., but thermal analysis studies indicate that calcium chloride hexahydrate begins to form at —54° and that the last of the brine probably solidifies at a temperature just below that.

Deposition of Salts from Sea Water by Frigid Concentration, *PB 111606, 34 pages; $1.00.*

Radio-Interference Manual To Assist Manufacturers

To assist manufacturers of equipment for the Armed Forces in meeting the requirements of radio-interference specifications a manual prepared by the Signal Corps Laboratories, Ft. Monmouth, N. J. has been made available to industry.

Radio-interference suppression has become increasingly important because of the large increase in the number and sensitivity of communications systems. Radio-interference specifications are now part of all detailed specifications for Armed Forces equipment, and many manufacturers with no previous experience in this field must apply radio-interference systems to items ranging from refrigerators to helicopters, from computing machines to tactical vehicles.

This manual contains information on approved suppression components and systems and their application. In addition, it explains the procedures recommended for obtaining approvals, requesting tests by the Signal Corps, and getting assistance from the Signal Corps in solving special problems. It concludes with a brief outline of basic principles.

Some of the individual sources of radio interference dealt with are rotating machinery, ignition systems, switches and contractors, electronic devices, fluorescent lamps and instruments. The book also discusses the suppression of complete equipment such as vehicles, marine equipment, airplanes and helicopters, diesel electric locomotives and teletypewriters.

Radio Interference Suppression Techniques, *PB 111611, 270 pages, $6.75.*

Packaging Ball Bearings

In a test conducted for Wright Air Development Center, it was found that certain volatile corrosion inhibitors are effective in preventing corrosion of packaged ball bearings. Bearings with or without an oil film were sealed in tin cans or flexible water vaperproof pouches with one of six volatile corrosion inhibitors and were then subjected to a three week cyclic exposure plus 60 days of storage at 120°F. and 92% relative humidity.

The inhibitor consisting of a kraft paper impregnated with sodium nitrite, urea and monoethanolamine benzoate gave the best results under all test conditions. A kraft paper impregnated with an amine salt also protected the bearings from corrosion under all conditions, except when used in a pouch exposed to 160°F. Generally, use of an oil film in conjunction with a VCI material did not reduce corrosion.

Packaging Requirements for Bearings, *PB 111650, 29 pages; $.75.*

Diffusion Studies in Titanium

Three reports of titanium research for the Armed Forces, two on diffusion and one on spectrochemical analysis, have been released to industry.

Diffusion of iron, nickel and cobalt into hot-pressed titanium carbide was studied using the radioactive isotopes of these transition metals. Calculation of the diffusion coefficients was made both by the surface decrease method and by the determination of the concentration gradient within the sample. Measurements of the diffusion coefficients were made at 900°

1000° and 1100°C but evidence is presented that diffusion is dependent upon the structure of the sample. Grain boundary diffusion appears to be the predominant type occurring.

Diffusion of Iron, Nickel and Cobalt Into Hot-Pressed Titanium Carbide, *PB 111612, 32 pages with tables, graphs and photomicrographs; $1.00.*

Technical papers and discussions are presented in the second report by authorities on titanium from military research facilities, universities and private research institutions, on such subjects as the diffusion of hydrogen, nitrogen and oxygen, volume diffusion of carbon, the effect of hydrogen on the ultrasonic attenuation in titanium, the effect of temperature on slip and twinning in titanium, and the plasticity of beta titanium.

Minutes of Titanium Symposium on Diffusion and Mechanical Behavior, *PB 111567, 59 pages, $1.50.*

The final report of the project deals with the study of spectrochemical methods for the analysis of titanium and titanium base alloys. The analysis for iron and vanadium in concentrations of about 2.5 per cent by the porous-cup technique, porous-cup analysis for boron below 0.1 per cent, a-c arc excitation with the porous-cup technique, and the analysis of titanium metals by direct sparking are discussed. In addition, the work performed since initiation of the project is summarized.

Spectrochemical Analysis of Titanium Metals and Alloys, *PB 111587, 32 pages with graphs and tables, $1.00.*

High Temperature Applications Of Molybdenum

Since the commercial development of the steam turbine, engineers have sought continuously for materials which would permit them to increase operating temperatures. One base metal after another has been used to the fullest extent of its capabilities and still the jet propulsion and gas turbine managers are far from satisfied.

Interest and experimentation at the present time are divided into three broad categories: improved cermets with better resistance to impact and thermal shock; vacuum melting processes to produce better nickel and cobalt base materials; and search for a coating material to protect metallic molybdenum from oxidizing at elevated temperatures. Solution to the latter problem would open temperature fields considerably higher than the 1650°F. maximum for present jet engines. The development, therefore, is being watched with keen interest both by aeronautical engineers and military officials.

A compilation of all available technical and fabricating data on arc-cast molybdenum is presented in a 72 page booklet just published by Climax Molybdenum Company. It is designed to provide those interested in the high temperature applications of molybdenum with a complete picture of where it stands today and possible uses in the very near future.

Booklet free upon request to Director of Technical Information, Climax Molybdenum Co., 500 Fifth Ave., New York 36, N.Y.

Better Torsion Testing Machine Developed

A new Kinetic Torsion Impact Tester designed by Pitman-Dunn Labs to fulfill Army Ordnance Corps requirements, not only produces shear fractures but permits accurate determining and recording of energy and torque values and indicates how applied torques and the specimen's resistance fluctuate during testing.

Torsion testing machines previously used generally indicated only a single value of tortional resistance and frequently caused brittle fracture or deformation in metals of high or low hardness.

Essential features of the machine are an electric motor with a heavy flywheel attached to its armature; a freely rotatable specimen collar with clutch teeth, which rotates with the specimen; and a fixed member with clutch teeth to hold the specimen stationary while it is twisted to fracture by the flywheel.

Methods of measuring energy and twist required to fracture, torque and torque vs. time to fracture are detailed in this report, with photographs and diagrams of the devices used and their operation. Preparation of the specimens, chiefly carbon alloy steel and non-ferrous metals, is described, and test results charted.

Improved Method for Testing in Torsion Impact, *PB 111613, 22 pages; $.75.*

Ignition Properties of Fuels

To achieve a better understanding of the relationship between fuel composition and ignition properties, and to develop a simple and rapid method of testing small quantities of fuels, additives, pure hydrocarbons and other compounds, the Naval Research Laboratory has conducted a series of experiments.

This work has been spurred by the rapidly increasing use of high-quality fuel and distillate stocks in jet aircraft, home burners and other equipment, in competition with the Navy's need for large quantities of diesel fuel, or suitable substitutes, for the Fleet. The purpose of these studies is to investigate the possibility of bolstering the supply of high cetane straight-run fuel by the use of low cetane fuels. Numerous methods of evaluating ignition behavior were tried out, and a controlled ignition meter was developed especially for these tests.

Among the subjects investigated were the ignition behavior of individual pure hydrocarbons of various types, the behavior of ignition improvers in pure form and in mixture with pure hydrocarbons, the relationships between ignition point, cetane number, and ignition delay, the effect of temperature and oxygen percent on ignition and characteristic minimum ignition points of isomeric hexanes.

Ignition Studies, Part IV, Relation of Minimum Ignition Point to Other Ignition Phenomena, *PB 111614, 15 pages; $.50.*

Transistorization of an Electronic Counter

Details of design and construction of a frequency meter using transistors instead of vacuum tubes are given in an Army Signal Corps research report.

Prior to construction of this electronic counter, a year was devoted to background study, transistor switching circuit study, decade counter development, control circuit development and frequency meter design. The complete frequency meter was then designed and built using plug-in construction and all-transistor circuitry, and the equipment was tested.

Application of Transistors to Electronic Counting Equipment, *PB 111610, 77 pages with circuit diagrams, drawings and photographs; $2.00. Also available is a catalog on Government research reports on the transistor, CTR-310, $.10.*

Analysis of Waxes in Lubricating Oils

As part of a research program to determine a more effective method of lowering the pour-point of lubricating oils, 10 straight chain hydrocarbons were studied in detail and their properties are given in an Air Force research report.

Below the pour-point the waxes in lubricating oil crystallize to form a coherent three-dimensional network throughout the oil preventing further flow. The pour-point is usually lowered by dewaxing or by using a pour-point depressant which modifies the crystal habit of the crystallizing wax.

In this study, the morphological, X-ray and optical properties of the 10 hydrocarbons from $C_{21}H_{44}$ to $C_{30}H_{62}$ are presented with as much information as possible on the polymorphic forms of each member of the series. The relationship between the crystallographic properties of these waxes and their behavior in lubricating oils is discussed. Representative binary composition diagrams were determined by a coordinated microscopical and X-ray diffraction approach.

Details of several new items of equip-

continued

ment developed for these tests are discussed in the report. These items include two hot stages for use with the phase microscope and an X-ray camera.

Characterization of C_{21}-C_{30} Hydrocarbons and Their Mixtures, *PB 111646, 104 pages, $2.75.*

Mass Production of Precision Ground Crystals

An improved sphere generator for precision contouring of round quartz crystals on a mass production basis has been developed by Bausch and Lomb under Army Signal Corps contract. The machine grinds spherical bevels on one or more flat round crystals at a time, with a range of curves from 29 mm to 350 mm. Curves even shorter can be generated with slight modifications in the machine and its auxiliary equipment.

Three pieces of high precision equipment, representing improvements on previously used models, were specially designed and built for this job. They were a modified lens generator, a unique blocking and centering feature and a measuring microscope.

Contouring Equipment for Round Crystals, *PB 111609, 60 pages, $1.50.*

Radioactive Battery

An investigation by the Army Signal Corps of the contact potential (that existing between two dissimilar metals in contact with each other) and the use of this physical phenomenon in a radioactive battery indicates that this type of battery is useful for producing small currents, for which there are numerous applications.

A 97-cell aluminum and copper plate battery, using a 250 KV X-ray machine as the ionizing agent, was first constructed and tested. Construction and testing of a 212-cell battery using a radioactive source of ionization followed. Aluminum and copper plates were used with a thallium 204 beta particle source as the ionizing agent and Xenon as the inert gas.

Radioactive Battery, *PB 111604, 39 pages; $1.00.*

Infrared Bibliography

A bibliography on infrared radiation has been compiled by the Library of Congress. The classification proceeds from infrared theory and general infrared—optical properties through various elements and components of infrared equipment, infrared spectroscopy and photography, to its applications in science, technology, the arts and industry.

Infrared: A Library of Congress Bibliography, *PB 111643, 374 pages; $3.00.*

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